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(54) **MONOCLONAL ANTIBODY DIRECTED AGAINST CD20 ANTIGEN**

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A61K 39/395	(2006.01)
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A61K 39/00	(2006.01)

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CPC ***C07K 16/2896*** (2013.01); ***A61K 51/1069*** (2013.01); ***C07K 16/2887*** (2013.01); ***C07K 16/3061*** (2013.01); *A61K 2039/505* (2013.01); *C07K 2317/24* (2013.01); *C07K 2317/56* (2013.01); *C12N 2510/02* (2013.01)

(58) **Field of Classification Search**

CPC C07K 16/2887; A61K 39/39541
See application file for complete search history.

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(57) **ABSTRACT**

The invention is directed to a monoclonal antibody directed against CD20 antigen, for therapeutic administration to humans, wherein each of the light chains of the antibody is encoded by murine-human chimeric nucleic acid sequence SEQ ID No. 27, and each of the heavy chains of the antibody is encoded by murine-human chimeric nucleic acid sequence SEQ ID No. 19. The invention is further directed to methods of in vitro activation of FcγRIIIA receptors in immune effector cells with the antibody and methods of treating CD20-expressing leukaemia or lymphoma with the antibody.

12 Claims, 10 Drawing Sheets

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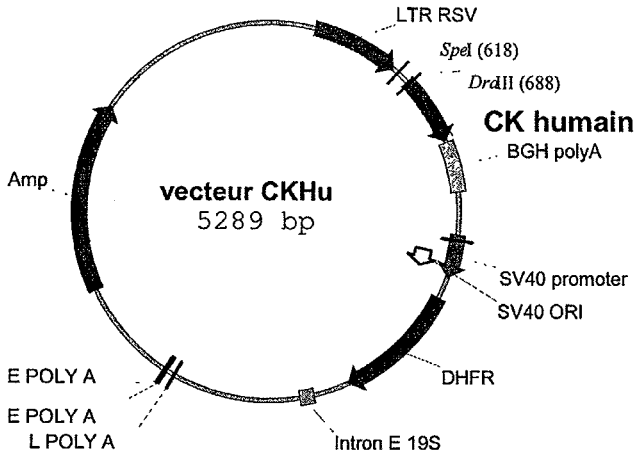
LTR RSV
SpeI (618)
DraIII (688)
CK humain
BGH polyA
Amp
vecteur CKHu
5289 bp
SV40 promoter
SV40 ORI
E POLY A
DHFR
E POLY A
L POLY A
Intron E 19S

FIG. 1

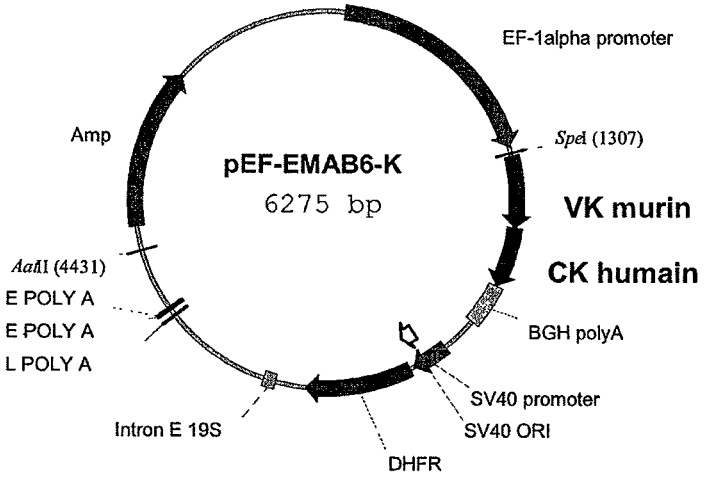
EF-1alpha promoter
Amp
SpeI (1307)
pEF-EMAB6-K
6275 bp
VK murin
CK humain
AatII (4431)
E POLY A
E POLY A
L POLY A
BGH polyA
SV40 promoter
SV40 ORI
Intron E 19S
DHFR

FIG. 2

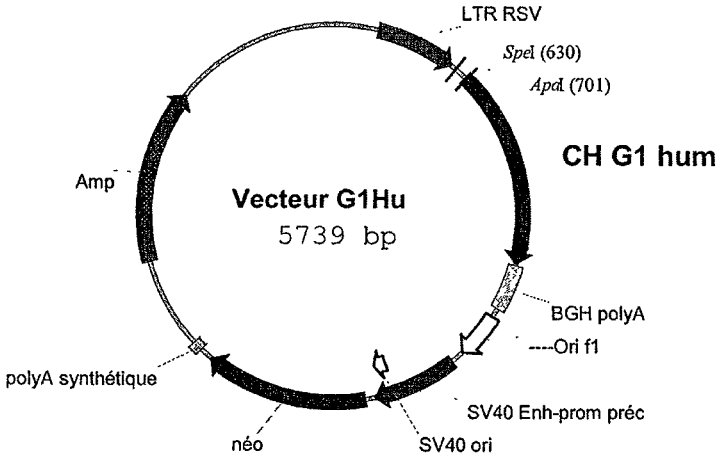
LTR RSV
SpeI (630)
ApaL (701)
CH G1 hum
Amp
Vecteur G1Hu
5739 bp
BGH polyA
----Ori f1
polyA synthétique
SV40 Enh-prom préc
néo
SV40 ori

FIG. 3

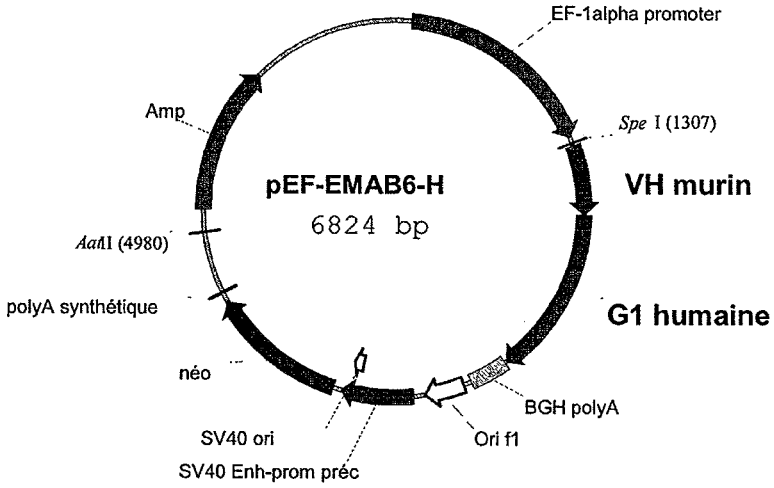
EF-1alpha promoter
Amp
Spe I (1307)
pEF-EMAB6-H
6824 bp
VH murin
AatII (4980)
G1 humaine
polyA synthétique
néo
BGH polyA
SV40 ori
Ori f1
SV40 Enh-prom préc

FIG. 4

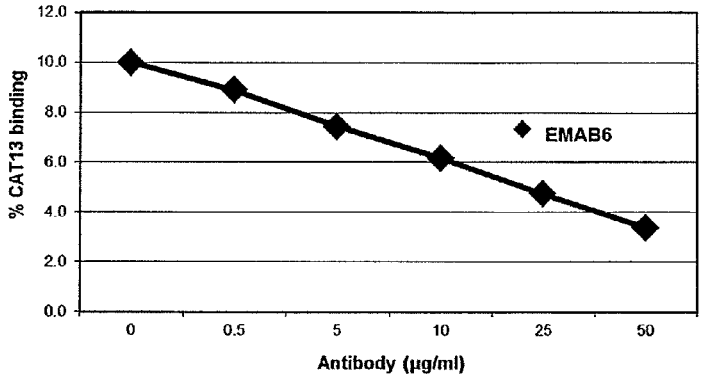
12.0
10.0
8.0
6.0
4.0
2.0
0.0
% CAT13 binding
EMAB6
0
0.5
5
10
25
50
Antibody (µg/ml)

FIG. 5

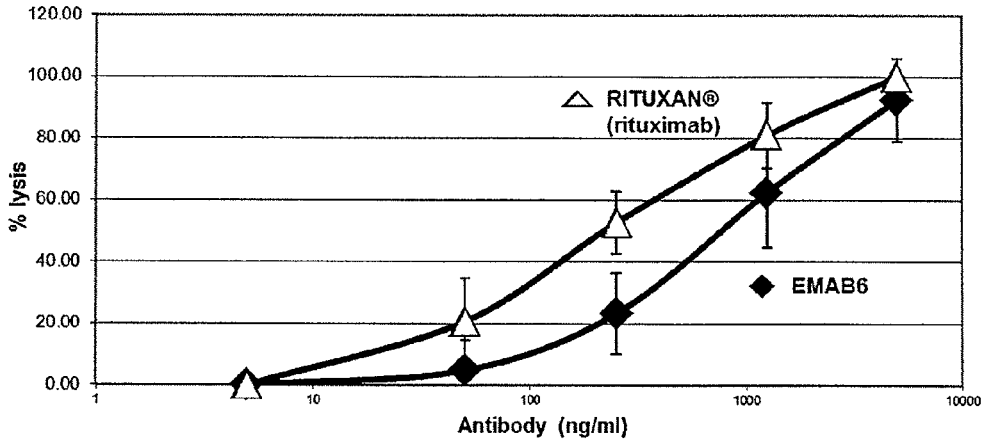
120.00
100.00
80.00
60.00
40.00
20.00
0.00
% lysis
RITUXAN®
(rituximab)
EMAB6
1
10
100
1000
10000
Antibody (ng/ml)

FIG. 6A

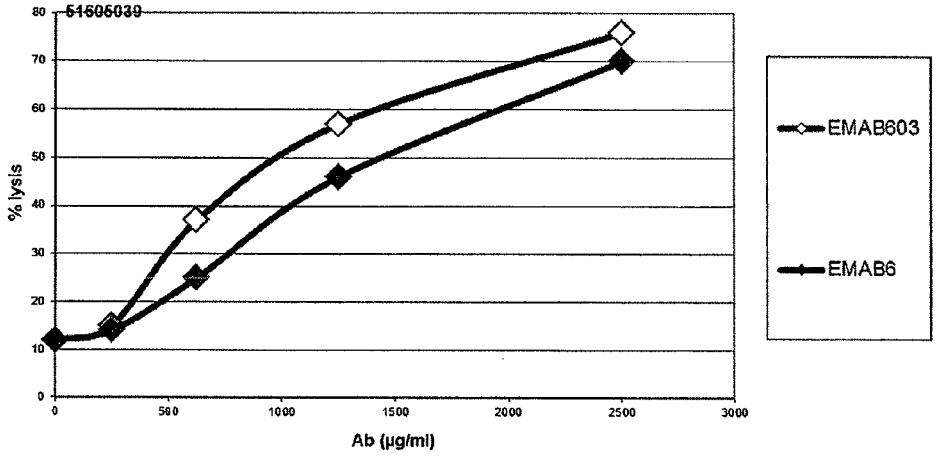
51606039
80
70
60
50
40
30
20
10
0
% lysis
0
500
1000
1500
2000
2500
3000
Ab (µg/ml)
EMAB603
EMAB6

FIG. 6B

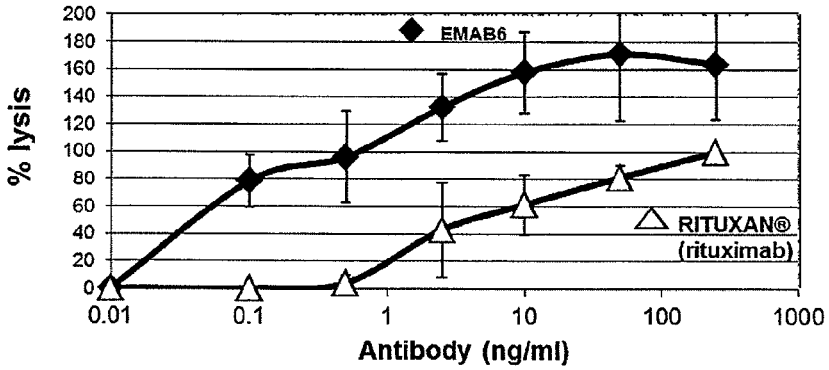
% lysis
200
180
160
140
120
100
80
60
40
20
0
EMAB6
RITUXAN®
(rituximab)
0.01
0.1
1
10
100
1000
Antibody (ng/ml)

FIG. 7A

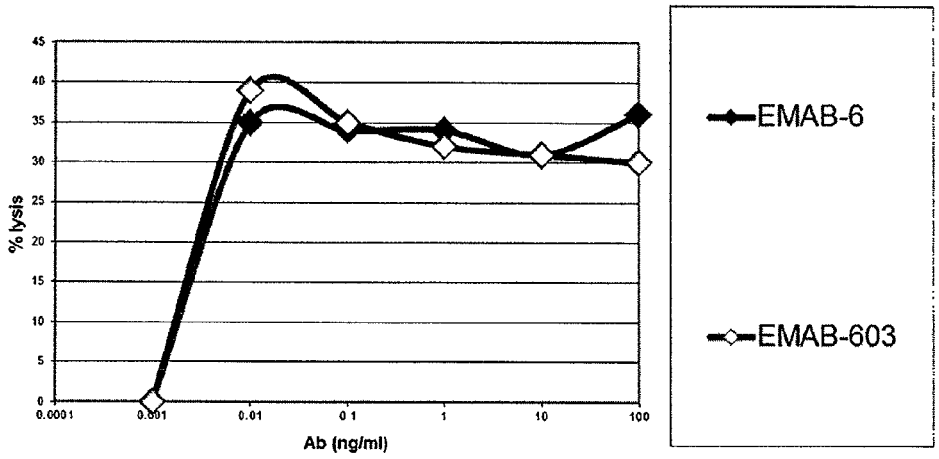
% lysis
45
40
35
30
25
20
15
10
5
0
0.0001
0.001
0.01
0.1
1
10
100
Ab (ng/ml)
EMAB-6
EMAB-603

FIG.7B

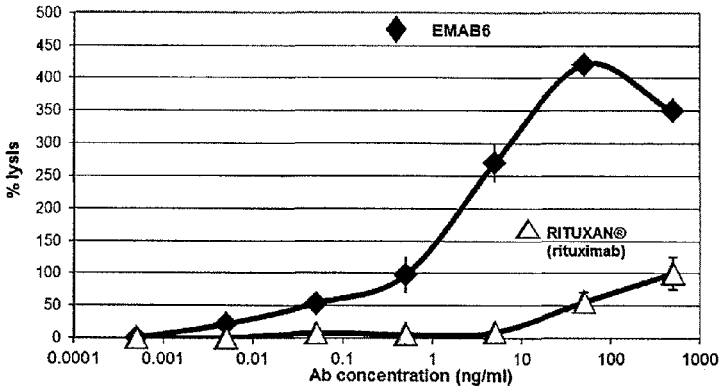
500
450
400
350
300
250
200
150
100
50
0
% lysis
EMAB6
RITUXAN®
(rituximab)
0.0001
0.001
0.01
0.1
1
10
100
1000
Ab concentration (ng/ml)

FIG. 8

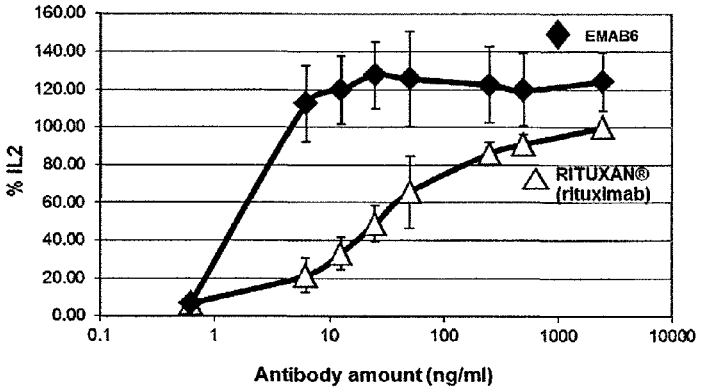
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
% IL2
0.1
1
10
100
1000
10000
Antibody amount (ng/ml)
EMAB6
RITUXAN®
(rituximab)

FIG. 9A

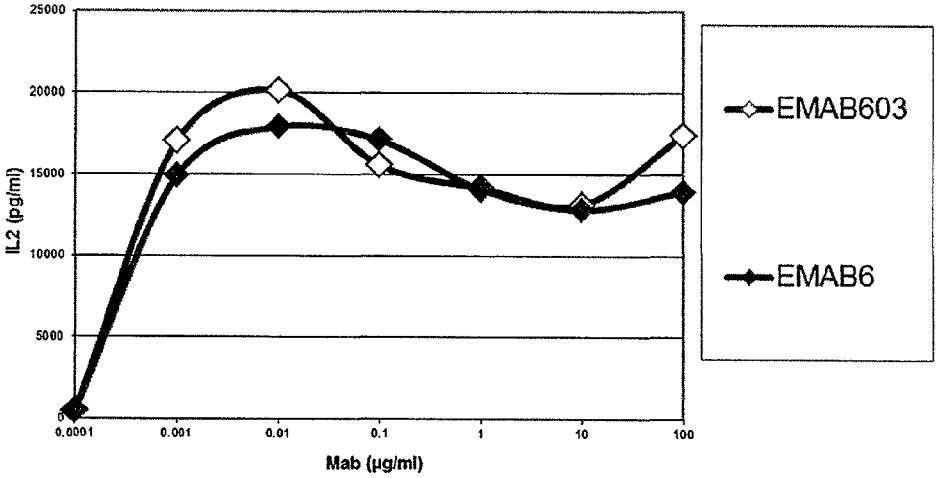
25000
20000
15000
10000
5000
0
IL2 (pg/ml)
0.0001
0.001
0.01
0.1
1
10
100
Mab (µg/ml)
EMAB603
EMAB6

FIG. 9B

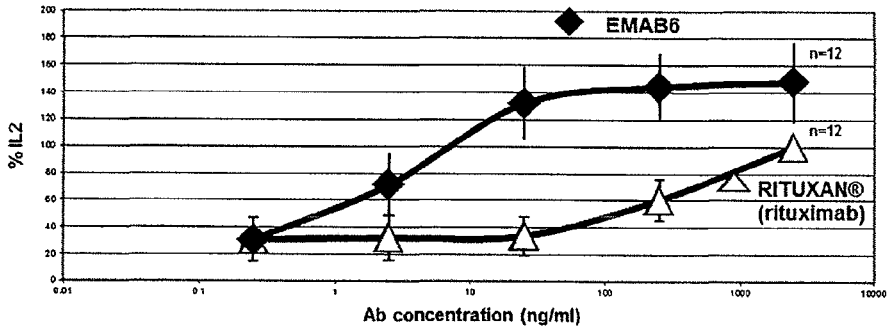
% IL2
0.01
0.1
1
10
100
1000
10000
Ab concentration (ng/ml)
EMAB6
n=12
n=12
RITUXAN®
(rituximab)

FIG. 10

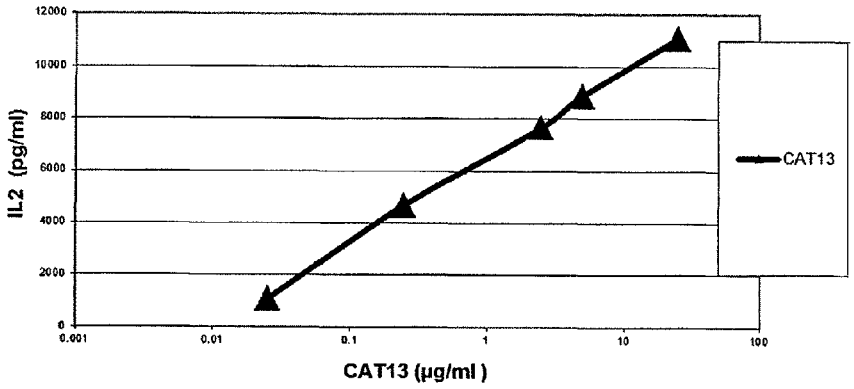
12000
10000
8000
6000
4000
2000
0
IL2 (pg/ml)
0.001
0.01
0.1
1
10
100
CAT13 (µg/ml)
CAT13

FIG. 11

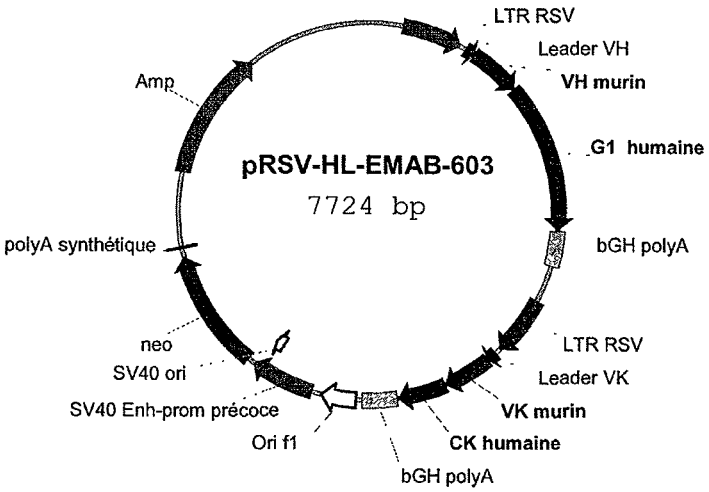
LTR RSV
Leader VH
VH murin
G1 humaine
bGH polyA
LTR RSV
Leader VK
VK murin
CK humaine
bGH polyA
Ori f1
SV40 Enh-prom précoce
SV40 ori
neo
polyA synthétique
Amp
pRSV-HL-EMAB-603
7724 bp

FIG.12

MONOCLONAL ANTIBODY DIRECTED AGAINST CD20 ANTIGEN

This application is the national stage of International Application PCT/FR2005/003123, filed in France on Dec. 14, 2005 and claiming priority on French Application No. 004 13320, filed in France on Dec. 15, 2004.

The present invention relates to a monoclonal antibody directed against the CD20 antigen, in which the variable regions of each of the light chains are encoded by sequences which share at least 70% sequence identity with murine nucleic acid sequence SEQ ID No. 5, the variable region of each of the heavy chains are encoded by sequences which share at least 70% identity with murine nucleic acid sequence SEQ ID No. 7, and the constant regions of the light and heavy chains are constant regions from a non-murine species, as well as to the use of such an antibody for activating FcγRIII receptors in immune effector cells and for the manufacture of a drug, in particular for the treatment of leukaemia or lymphoma.

INTRODUCTION AND PRIOR ART

The CD20 antigen is a hydrophobic transmembrane protein with a molecular weight of 35-37 kDa which is present on the surface of mature B lymphocytes (Valentine et al. (1987) *Proc. Natl. Acad. Sci. USA* 84(22): 8085-8089; Valentine et al. (1989) *J. Biol. Chem.,* 264(19): 11282-11287). It is expressed during the development of B lymphocyte cells (B cells) as from the early pre-B stage until differentiation into plasmocytes, a stage at which this expression disappears. The CD20 antigen is present on both normal B lymphocytes and malign B cells. More specifically, the CD20 antigen is expressed on most phenotype-B lymphomas (80% lymphomas): for example, it is expressed on over 90% non-Hodgkin's B-cell lymphomas (NHL) and over 95% B-type Chronic Lymphocytic Leukaemia (B-CLL). The CD20 antigen is not expressed on haematopoietic stem cells and on plasmocytes.

The function of CD20 has not yet been fully clarified, but it may act as a calcium channel and be involved in the regulation of the first stages of B lymphocytes differentiation (Golay et al. (1985) *J. Immunol.* 135(6): 3795-3801) and proliferation (Tedder et al. (August 1986) *Eur. J. Immunol.* 16(8): 881-887).

Therefore, although some uncertainty remains as regards its role in the activation and proliferation of B cells, the CD20 antigen is, because of its location, an important target for the treatment of conditions which involve tumoural B cells, such as NHL or B-CLL for instance, using antibodies which specifically recognise CD20. Furthermore, this antigen is an ideal target since it is a membrane protein for which no expression modulation or polymorphism is known.

Only one non-radioactively labelled anti-CD20 monoclonal antibody, Rituxan® (rituximab, Genentech), is currently commercially available for the treatment of B-cell lymphoma. It shows encouraging clinical results in patients with NHL when associated with chemotherapy. Its effectiveness, however, remains variable and frequently modest when it is used alone (Teeling et al. (2004) *Blood* 104(6):1793-1800).

In addition, Rituxan® has only a modest effect on B cells in B-CLL. This low degree of effectiveness has been correlated with various phenomena: on the one hand, B-CLL B cells only express CD20 in relatively low quantities, and on the other hand, Rituxan® only induces very low ADCC (Antibody-Dependent Cellular Cytotoxicity) activity levels against these cells in vitro. These two observations might explain the correlation that has been observed between the level of expression of CD20 on tumours (in quantitative flow cytometry) and response to treatments.

Since B-CLL is the commonest form of leukaemia in western countries, and high-dose chemotherapy treatment sometimes prove to be insufficient and involve side effects which lead to haematopoietic aplasia and immunodeficiency, monoclonal antibodies appear to be an innovative approach. It is therefore of primary importance to develop antibodies which are capable of specifically targeting the CD20 antigen and which allow tumour cells such as B-CLL, which only express this antigen to a limited degree, to be destroyed.

Antibodies 2F2 and 7D8, proposed by Genmab (Teeling et al. (2004) *Blood* 104(6): 1793-1800) for the treatment of B-CLL, have a capacity to activate the complement which is greater than that induced by Rituxan®. These antibodies, however, have a low ADCC activity, similar to that of Rituxan®. Yet, some clinicians have shown that the complement activity is the cause of deleterious side effects, as the antibodies trigger an activation system which leads to the production of molecules (in particular, anaphylatoxins) which have a wide spectrum of non-specific activities (inflammatory, allergic or vascular reactions etc.). In addition, these antibodies are still at the research stage and their clinical effectiveness has yet to be evaluated.

In application FR03/02713 (WO 2004/029092), the present Applicant describes an anti-CD20 antibody which can be produced in the YB2/0 line and which has been selected for its ability to induce a high ADCC activity and a high level of IL-2 production by the Jurkat-CD16 cell compared to Rituxan®. There is a significant need for new anti-CD20 antibodies which will allow the range of B-cell diseases treated using the currently available immunotherapies to be extended; this is particularly the case with B-cell diseases in which the CD20 antigen is expressed to a small degree on the populations of B cells involved, and for which no satisfactory immunotherapies exist.

It is with this purpose in mind that the present Applicant has developed new CD20 antibodies which exhibit a particularly high ADCC activity compared to Rituxan®.

SUMMARY OF THE INVENTION

A first object of the invention therefore relates to a monoclonal antibody directed against the CD20 antigen, in which the variable region of each of the light chains is encoded by a sequence which shares at least 70% identity with murine nucleic acid sequence SEQ ID No. 5, the variable region of each of the heavy chains is encoded by a sequence which shares at least 70% identity with murine nucleic acid sequence SEQ ID No. 7, and the constant regions of the light and heavy chains are constant regions from a non-murine species.

DESCRIPTION

The antibodies are made up of heavy and light chains linked together by disulphide bonds. Each chain is made up, in the N-terminal position, of a variable region (or domain) (encoded by rearranged V-J genes for the light chains and V-D-J genes for the heavy chains) specific to the antigen against which the antibody is directed, and, in the C-terminal position, of a constant region made up from a single CL domain for the light chains, or several domains for the heavy chains.

For the purposes of the invention, the expressions "monoclonal antibodies" or "monoclonal antibody composition" refer to a preparation of antibody molecules having identical and unique specificities.

The antibody according to the invention, in which the variable regions in the light and heavy chains are from a species which is different from that of the constant regions of the light and heavy chains, is referred to as a "chimeric" antibody.

Murine nucleic acid sequences SEQ ID No. 5 and SEQ ID No. 7 code for the variable domain of each of the light chains and the variable domain of each of the heavy chains respectively, of the antibody produced by murine hybridoma CAT-13.6E12, available at the Deutsche Sammlung von Mikroorganismen und Zellkulturen GmbH (DSMZ) under number ACC 474. This hybridoma produces a murine IgG2a, κ-type monoclonal antibody directed against CD20.

These murine sequences were chosen to derive the sequences of the variable regions of the antibodies according to the invention because of the specificity of the CAT-13.6E12 murine antibody for the CD20 antigen, the antigen also recognised by Rituxan®. The variable regions of the antibodies according to the invention share at least 70% identity with sequences SEQ ID No. 5 and SEQ ID No. 7, with this sequence identity providing the antibodies according to the invention with a specificity which is identical to that of the CAT-13.6E2 murine antibody. Preferably, this sequence identity also provides the antibody according to the invention with an affinity for the target which is identical to that of the CAT-13.6E12 murine antibody.

In addition, the present Applicant has surprisingly shown that the CAT-13.6E12 murine antibody has the ability to induce the secretion of IL-2 in the presence of Jurkat-CD16 cells which express ectodomains of the FcγRIIIA receptor (as shown in FIG. **11**), indicating a strong binding between the murine antibody and human CD16 (FcγRIIIA), which again motivated the choice made by the present Applicant.

In addition, in the antibodies according to the invention, the constant regions of the light and heavy chains are from a non-murine species. In this regard all non-murine mammal species and families may be used, in particular humans, monkeys, murine (apart from mice), porcine, bovine, equine, feline, canine, as well as birds.

The antibodies according to the invention may be constructed using standard recombinant DNA techniques, well known to those skilled in the art, and more particularly using the "chimeric" antibody construction techniques described, for example, in Morrison et al. (1984) *Proc. Natl. Acad. Sci.* USA 81: 6851-6855, where the recombinant DNA technology is used to replace the constant region of a heavy chain and/or the constant region of a light chain in an antibody from a non-human mammal, with the corresponding regions in an human immunoglobulin. One particular embodiment will be illustrated below.

Advantageously, the variable region of each of the light chains of the antibody according to the invention is encoded by a sequence which shares at least 80% identity with murine nucleic acid sequence SEQ ID No. 5, and the variable region of each of the heavy chains of the antibody according to the invention is encoded by a sequence which shares at least 80% identity with murine nucleic acid sequence SEQ ID No. 7.

Advantageously, the variable region of each of the light chains of the antibody according to the invention is encoded by a sequence which shares at least 90% identity with murine nucleic acid sequence SEQ ID No. 5, and the variable region of each of the heavy chains of the antibody according to the invention is encoded by a sequence which shares at least 90% identity with murine nucleic acid sequence SEQ ID No. 7.

Advantageously, the variable region of each of the light chains of the antibody according to the invention is encoded by a sequence which shares at least 95% identity with murine nucleic acid sequence SEQ ID No. 5, and the variable region of each of the heavy chains of the antibody according to the invention is encoded by a sequence which shares at least 95% identity with murine nucleic acid sequence SEQ ID No. 7.

Advantageously, the variable region of each of the light chains of the antibody according to the invention is encoded by a sequence which shares at least 99% identity with murine nucleic acid sequence SEQ ID No. 5, and the variable region of each of the heavy chains of the antibody according to the invention is encoded by a sequence which shares at least 99% identity with murine nucleic acid sequence SEQ ID No. 7.

Advantageously, the invention also relates to any antibody in which the variable regions of the heavy and light chains include one or more substitution(s), insertion(s) or deletion(s) of one or more amino acids, with these sequence modifications complying with the sequence identity percentage levels defined above, without affecting the antibodys' specificity or affinity for the target.

The antibodies of the invention are also any antibody which includes the CDRs (Complementary Determining Regions) of the CAT-13.6E12 antibody, combined with FR (framework) regions (highly conserved regions of the variable regions, also known as "backbone" regions). Such antibodies have affinities and specificities which are closely comparable with, and preferably identical to, those of the CAT-13.6E12 murine antibody.

Preferably, the variable region of each of the light chains of the antibody according to the invention is encoded by murine nucleic acid sequence SEQ ID No. 5 or by murine nucleic acid sequence SEQ ID No. 25, and the variable region of each of the heavy chains of the antibody according to the invention is encoded by murine nucleic acid sequence SEQ ID No. 7.

In one embodiment of the invention, an antibody according to the invention is therefore a monoclonal antibody directed against the CD20 antigen, in which the variable region of each of the light chains is encoded by murine nucleic acid sequence SEQ ID No. 5, the variable region of each of the heavy chains is encoded by murine nucleic acid sequence SEQ ID No. 7, and the constant regions of the light and heavy chains are constant regions from a non-murine species.

In a second embodiment, the antibody according to the invention is therefore a monoclonal antibody raised against the CD20 antigen, in which the variable regions of each of the light chains are encoded by murine nucleic acid sequence SEQ ID No. 25, the variable regions of each of the heavy chains are encoded by murine nucleic acid sequence SEQ ID No. 7, and the constant regions of the light and heavy chains are constant regions from a non-murine species.

In both embodiments, the antibodies differ in their nucleotide sequences by a single nucleotide: the nucleotide located at position 318 in SEQ ID No. 5 and SEQ ID No. 25, which correspond to a cytosine and an adenine respectively.

The antibodies of the invention according to these embodiments have specificities and affinities for the target antigen, CD20, which are comparable with, and preferably identical to, those of the CAT-13.6E12 murine antibody.

Preferably, the constant regions of each of the light chains and each of the heavy chains of the antibody according to the invention are human constant regions. In this preferred embodiment of the invention, the immunogenicity of the

antibody is reduced in humans, and consequently, the antibodys' effectiveness is improved upon therapeutic administration to humans.

According to a preferred embodiment of the invention, the constant region of each of the light chains of the antibody according to the invention is of κ type. Any allotype is suitable for the implementation of the invention, e.g. Km(1), Km(1, 2), Km(1, 2, 3) or Km(3), but the preferred allotype is Km(3).

According to another additional embodiment, the constant region of each of the light chains of the antibody according to the invention is of λ type.

According to one specific aspect of the invention, and in particular when the constant regions of each of the light chains and of each of the heavy chains of the antibody according to the invention are human regions, the constant region of each of the heavy chains of the antibody is of γ type. According to this alternative, the constant region of each of the heavy chains of the antibody may be of γ1, γ2 or γ3 type, with these three constant region types exhibiting the specific feature of binding the human complement, or even of γ4 type. Antibodies which have γ-type constant regions for each of the heavy chains belong to the IgG class. Immunoglobulins G (IgG) are heterodimers made up of 2 heavy chains and 2 light chains, linked together by disulphide bonds. Each chain is made up, in the N-terminal position, of a variable region or domain (encoded by rearranged V-J genes for the light chains and V-D-J genes for the heavy chains) specific to the antigen against which the antibody is directed, and, in the C-terminal position, of a constant region made up of a single CL domain for the light chain, or of 3 domains (CH_1, CH_2 and CH_3) for the heavy chain. Combining the variable domains and the CH_1 and CL domains of the heavy and light chains make up the Fab fragments which are linked to the Fc regions through a highly flexible hinge region allowing each Fab fragment to bind its antigen target whilst the Fc region, the mediator for the effector properties of the antibody, remains accessible to effector molecules such as FcγR and C1q receptors. The Fc region, made up of both CH_2 and CH_3 globular domains, is glycosylated at the CH_2 domain, with a lactosamine-type biantennary N-glycan linked to Asn 297 being present on each of the 2 chains.

Preferably, the constant region of each of the heavy chains of the antibody is of γ1 type, as such antibody exhibits the ability to induce ADCC activity in the greatest number of (human) individuals. In this respect, any allotype is suitable for the implementation of the invention, e.g. G1m(3), G1m(1, 2, 17), G1m(1, 17) or G1m(1, 3). Preferably, the allotype is G1m(1, 17).

According to one particular aspect of the invention, the constant region of each of the heavy chains of the antibody is of γ1 type, and is encoded by human nucleic acid sequence SEQ ID No. 23, with the constant region of each of the light chains being encoded by human nucleic acid sequence SEQ ID No. 21. Such an antibody therefore includes a murine variable region and a human constant region, with γ1-type heavy chains. This antibody therefore belongs to the IgG1 sub-class. According to the embodiment of the antibody according to the invention, the antibody has two light chains, the variable domain of which is encoded by murine nucleic acid sequence SEQ ID No. 5 or murine nucleic acid sequence SEQ ID No. 25, and the human constant region of which is encoded by nucleic acid sequence SEQ ID No. 21, and two heavy chains, the variable domain of which is encoded by murine nucleic acid sequence SEQ ID No. 7 and the constant region of which is encoded by human nucleic acid sequence SEQ ID No. 23.

Preferentially, each of the light chains of the antibody according to the invention is encoded by murine-human chimeric nucleic acid sequence SEQ ID No. 13 or by murine-human chimeric nucleic acid sequence SEQ ID No. 27, and each of the heavy chains is encoded by murine-human chimeric nucleic acid sequence SEQ ID No. 19. Murine-human chimeric nucleic acid sequence SEQ ID No. 13, which codes for each of the light chains of the antibody, is obtained by fusing murine nucleic acid sequence SEQ ID No. 5, which codes for the variable domain of each of the light chains of the antibody, to human nucleic acid sequence SEQ ID No. 21, which codes for the constant region of each of the light chains of the antibody.

Murine-human chimeric nucleic acid sequence SEQ ID No. 27, which codes for each of the light chains of the antibody, is obtained by fusing murine nucleic acid sequence SEQ ID No. 25, which codes for the variable domain of each of the light chains of the antibody, to human nucleic acid sequence SEQ ID No. 21, which codes for the constant region of the light chains of the antibody.

Murine-human chimeric nucleic acid sequence SEQ ID No. 19, which codes for each of the heavy chains of the antibody, is obtained by fusing murine nucleic acid sequence SEQ ID No. 7, which codes for the variable domain of each of the heavy chains of the antibody, to human nucleic acid sequence SEQ ID No. 23, which codes for the constant region of each of the heavy chains of the antibody.

According to a particular aspect of the invention, when each of the light chains of the antibody is encoded by murine-human chimeric nucleic acid sequence SEQ ID No. 13, and each of the heavy chains is encoded by murine-human chimeric nucleic acid sequence SEQ ID No. 19, the peptide sequence of each of the light chains, deduced from nucleic acid sequence SEQ ID No. 13, is sequence SEQ ID No. 14 and the peptide sequence of each of the heavy chains, deduced from nucleic acid sequence SEQ ID No. 19, is sequence SEQ ID No. 20.

According to a further particular aspect of the invention, when each of the light chains of the antibody is encoded by murine-human chimeric nucleic acid sequence SEQ ID No. 27, and each of the heavy chains is encoded by murine-human chimeric nucleic acid sequence SEQ ID No. 19, the peptide sequence of each of the light chains, deduced from nucleic acid sequence SEQ ID No. 27, is sequence SEQ ID No. 28, and the peptide sequence of each of the heavy chains, deduced from nucleic acid sequence SEQ ID No. 19, is sequence SEQ ID No. 20.

The peptide sequences SEQ ID No. 14 and SEQ ID No. 28 differ only by the amino acid present at position 106 on each of these two sequences. The amino acid located at position 106 is lysine (K) in sequence SEQ ID No. 28; it is asparagine (N) in sequence SEQ ID No. 14.

The invention also relates to antibodies in which each of the light chains encoded by murine-human chimeric nucleic acid sequence shares at least 70% homology or identity with murine-human chimeric nucleic acid sequence SEQ ID No. 13, and each of the heavy chains encoded by a murine-human chimeric nucleic acid sequence shares at least 70% homology or identity with the murine-human chimeric nucleic acid sequence SEQ ID No. 19, with these modifications adversely impairing neither the specificity of the antibody nor its effector activities, such as ADCC (Antibody-Dependent Cell-mediated Cytotoxicity) activity.

In a particularly advantageous manner, the antibody of the invention is produced by a rat hybridoma cell line. The line which produces the antibody according to the invention is an important characteristic since it provides the antibody with

certain of its particular properties. In fact, the method of expression of the antibody induces the post-translational modifications, in particular the glycosylation modifications, which may vary from one cell line to another, and therefore provides antibodies which have identical primary structures with different functional properties.

In a preferred embodiment, the antibody is produced in the rat hybridoma YB2/0 cell line (cell YB2/3HL.P2.G11.16Ag.20, registered at the American Type Culture Collection under ATCC number CRL-1662). This line was chosen because of its ability to produce antibodies with improved ADCC activity compared to antibodies with the same primary structures produced, for example, in CHO cells.

According to a specific embodiment, a preferred antibody according to the invention is antibody EMAB6 produced by clone R509, registered on 8 Nov. 2004 under registration number CNCM I-3314 at the Collection Nationale de Cultures de Microorganismes (CNCM, Institut Pasteur, 25 rue du Docteur Roux, 75724 Paris Cedex 15, France). Each of the light chains of the EMAB6 antibody is encoded by murine-human chimeric nucleic acid sequence SEQ ID No. 13, and each of the heavy chains is encoded by murine-human chimeric nucleic acid SEQ ID No. 19. This chimeric antibody competes with the CAT-13.6E12 murine antibody in binding CD20 and has a cytotoxic activity which is much greater than that of Rituxan®, which may be attributable in part to the specific glycosylation of the N-glycan of the heavy chain of these antibodies (see Example 4). In fact, a specific feature of the R509 clone is that it produces an EMAB6 antibody composition with a fucose/galactose ratio of less than 0.6, which has been shown, in patent application FR 03 12229, to be optimal to provide the antibody with strong ADCC activity. This antibody is therefore particularly interesting as a therapeutic tool for the treatment of conditions in which the cells to be targeted express CD20.

In a further specific embodiment, another preferred antibody according to the invention is antibody EMAB603 produced by clone R603, registered on 29 Nov. 2005 under registration number CNCM I-3529 at the Collection Nationale de Cultures de Microorganismes (CNCM, Institut Pasteur, 25 rue du Docteur Roux, 75724 Paris Cedex 15, France). Each of the light chains of the EMAB603 antibody is encoded by murine-human chimeric nucleic acid sequence SEQ ID No. 27, and each of the heavy chains is encoded by murine-human chimeric amino acid sequence SEQ ID No. 19. This chimeric antibody competes with the CAT-13.6E12 murine antibody in binding CD20 and has a cytotoxic activity which is much greater than that of Rituxan®, which may be attributable in part to the specific glycosylation of the N-glycan of the heavy chain of these antibodies (see Example 3). In fact, a specific feature of the R603 clone is that it produces an EMAB603 antibody composition with a fucose/galactose ratio of less than 0.6, (see Example 4) which has been shown, in patent application FR 03 12229, to be optimal to provide the antibody with strong ADCC activity. This antibody is therefore of particular interest as a therapeutic tool for the treatment of conditions in which the cells to be targeted express CD20.

Another object of the invention relates to vector pEF-EMAB6-K for the expression of the light chain of an antibody according to the invention, having sequence SEQ ID No. 12. This vector is the vector which allows an antibody according to the invention, the light chain of which is encoded by nucleic acid sequence SEQ ID No. 13, the deduced peptide sequence of which is sequence SEQ ID No. 14, to be expressed. This vector is a nucleic acid molecule into which murine nucleic acid sequence SEQ ID No. 5, which codes for the variable domain of each of the light chains of the antibody, and nucleic acid sequence SEQ ID No. 21, which codes for the constant regions of each of the light chains of the antibody, have been inserted to be introduced and maintained in a host cell. It allows foreign nucleic acid fragments to be expressed in the host cell since it has sequences (promoter, polyadenylation sequence, selection gene) which are essential to this expression. Such vectors are well known to those skilled in the art and may be, without implied limitation, an adenovirus, a retrovirus, a plasmid or a bacteriophage. In addition, any mammalian cell may be used as a host cell, that is as a cell which expresses the antibody according to the invention, e.g. YB2/0, CHO, CHO dhfr− (e.g. CHO DX B11, CHO DG44), CHO Lec13, SP2/0, NSO, 293, BHK or COS.

Another object of the invention relates to vector pEF-EMAB6-H for the expression of the heavy chain of an antibody according to the invention, having sequence SEQ ID No. 18. This vector is the vector which allows an antibody according to the invention, the heavy chain of which is encoded by nucleic acid sequence SEQ ID NO 19, the deduced peptide sequence of which is sequence SEQ ID No. 20, to be expressed. This vector is a nucleic acid molecule into which murine nucleic acid sequence SEQ ID No. 7, which codes for the variable domain of each of the heavy chains of the antibody, and human nucleic acid sequence SEQ ID No. 23, which codes for the constant region of each of the heavy chains of the antibody, have been inserted to be introduced and maintained in a host cell. It allows these foreign nucleic acid fragments to be expressed in the host cell since it has sequences (promoter, polyadenylation sequence, selection gene) which are essential to this expression. Just as indicated earlier, the vector may be, for example, a plasmid, an adenovirus, a retrovirus or a bacteriophage, and the host cell may be any mammalian cell, e.g. YB2/0, CHO, CHO dhfr− (CHO DX B11, CHO DG44), CHO Lec13, SP2/0, NSO, 293, BHK or COS.

An antibody produced by co-expressing the pEF-EMAB6-K and pEF-EMAB6-H vectors in the YB2/0 cell is illustrated by the anti-CD20 EMAB6 antibody, produced by clone R509 (registered under registration number CNCM I-3314 at the CNCM). This antibody induces a cytotoxicity which is greater than that induced by Rituxan®, both in cells from patients with B-CLL (on which the CD20 antigen is expressed at lower levels) and in Raji cells used as a model and which express CD20 at higher densities compared to the cells from patients with B-CLL. Furthermore, the EMAB6 antibody induces a secretion of IL-2 (interleukin 2) in Jurkat-CD16 cells which is at much higher levels than with Rituxan®. Since the EMAB6 antibody can be produced by growing the R509 clone in a culture medium and under conditions which allow the vectors described above to be expressed, it is therefore a very interesting tool for advancing the therapy and diagnosis of B-cell diseases in which the CD20 antigen is involved, more specifically B-CLL, as well as for research in this area.

A particular object of the invention is a stable cell line which expresses an antibody according to the invention.

Advantageously, the stable cell line which expresses an antibody according to the invention is selected from the group consisting of: SP2/0, YB2/0, IR983F, a human myeloma such as Namalwa or any other cell of human origin such as PERC6, the CHO lines, in particular CHO-K-1, CHO-Lec10, CHO-Lec1, CHO-Lec13, CHO Pro-5, CHO dhfr− (CHO DX B11, CHO DG44), or other lines chosen from Wil-2, Jurkat, Vero, Molt-4, COS-7, 293-HEK, BHK, K^6H^6, NSO, SP2/0-Ag 14 and P3X63Ag8.653.

The line used is preferably the rat hybridoma YB2/0 cell line. This line was chosen because of its ability to produce antibodies with improved ADCC activity with respect to antibodies with the same primary structure produced, for example, in CHO cells.

According to one particular aspect of the invention, the stable cell line which expresses an antibody according to the invention and which is more specifically chosen from the group described above, has incorporated the two pEF-EMAB6-K and pEF-EMAB6-H expression vectors as described earlier.

One specific aspect of the invention relates to clone R509, registered under registration number CNCM I-3314 at the Collection Nationale de Cultures de Microorganismes (CNCM).

One specific aspect of the invention relates to clone R603, registered under registration number CNCM I-3529 at the Collection Nationale de Cultures de Microorganismes (CNCM).

Another object of the invention relates to a DNA fragment having sequence SEQ ID No. 19 which codes for the heavy chain of an antibody according to the invention. Murine-human chimeric nucleic acid sequence SEQ ID No. 19 codes for each of the heavy chains of the antibody. It is obtained by fusing murine nucleic acid sequence SEQ ID No. 7, which codes for the variable domain of each of the heavy chains of the antibody, to human nucleic acid sequence SEQ ID No. 23, which codes for the constant region of each of the heavy chains of the antibody.

Another specific object of the invention relates to a DNA fragment having sequence SEQ ID No. 13, which codes for the light chain of an antibody according to the invention. Murine-human chimeric nucleic acid sequence SEQ ID No. 13 codes for each of the light chains of the antibody. It is obtained by fusing murine nucleic acid sequence SEQ ID No. 5, which codes for the variable domain of each of the light chains of the antibody, to human nucleic acid sequence SEQ ID No. 21, which codes for the constant region of each of the light chains of the antibody.

Another specific object of the invention relates to a DNA fragment having sequence SEQ ID No. 27, which codes for the light chain of an antibody according to the invention. Murine-human chimeric nucleic acid sequence SEQ ID No. 27, codes for each of the light chains of the antibody. It is obtained by fusing murine nucleic acid sequence SEQ ID No. 25, which codes for the variable domain of each of the light chains of the antibody, to human nucleic acid sequence SEQ ID No. 21, which codes for the constant region of each of the light chains of the antibody.

One specific object of the invention relates to the use of the antibody according to the invention to activate, in vivo or in vitro, the FcγRIIIA receptors of effector immune cells. In fact, the antibodies of the invention have the specific feature and advantage of being cytotoxic. As such, they exhibit the ability to activate FcγRIIIA receptor with their Fc regions. This is of considerable interest as this receptor is expressed on the surface of cells known as "effector cells": binding of the Fc region of the antibody to its receptor carried by the effector cell causes the activation of FcγRIIIA receptors and the destruction of the target cells. Effector cells are, for instance, NK (Natural Killer) cells, macrophages, neutrophils, CD8 lymphocytes, Tγδ lymphocytes, NKT cells, eosinophils, basophils or mastocytes.

In one specific aspect, the antibody of the invention is used as a drug. Advantageously, such a drug is intended for the treatment of conditions in which the target cells are cells which express CD20, such as malignant B-cell lymphoma.

According to one advantageous aspect, the antibody according to the invention is used to manufacture a drug for the treatment of leukaemia or lymphoma.

One specific object of the invention is the use of the antibody according to the invention for the manufacture of a drug for the treatment of a pathology selected from the group consisting of acute B lymphoblastic leukaemia, B-cell lymphoma, mature B-cell lymphoma, including B-type Chronic Lymphocytic Leukaemia (B-CLL), small B-cell lymphoma, B-cell prolymphocytic leukaemia, lymphoplasmocytic lymphoma, mantle cell lymphoma, follicular lymphoma, marginal zone MALT-type lymphoma, lymph node marginal zone lymphoma with or without monocytoid B cells, splenic marginal zone lymphoma (with or without villous lymphocytes), tricholeucocytic leukaemia, diffuse large B-cell lymphoma, Burkitt's lymphoma, as well as any immune dysfunction diseases involving B lymphoid cells, including autoimmune diseases.

Another object of the invention is the use of the antibody according to the invention for the manufacture a drug for the treatment of lymphoid leukaemia.

Another object of the invention is the use of the antibody according to the invention for the manufacture of a drug for the treatment of B-type Chronic Lymphoid Leukaemia (B-CLL). Furthermore, the antibody according to the invention is particularly well suited for the treatment of conditions in which CD20 is less strongly expressed on B cells, and preferably, B-CLL (B-type Chronic Lymphocytic Leukaemia). In this regard, the antibody according to the invention may be used in combination with one or more further antibody(ies), e.g. monoclonal antibodies directed against one or more further antigens expressed on lymphoid cells, such as, for example, antigens HLA-DR, CD19, CD23, CD22, CD80, CD32 and CD52, for the manufacture of a drug for the treatment of leukaemia or lymphoma. Thus, the humanised antibody Campath-1H® (alentuzumab, MabCampathR®) which targets a molecule which is abundantly expressed on lymphoid cells, the CD52 antigen, and which induces cell lysis by mobilising the host effector mechanisms (complement binding, antibody-dependent cytotoxicity) is used in the treatment of CLL (Moreton P., Hillmen P. (2003) *Semin. Oncol.* 30(4): 493-501; Rawstron A. C. et al, (2004) *Blood* 103(6): 2027-2031; Robak T. (2004) *Leuk. Lymphoma* 45(2): 205-219; Stanglmaier M. et al, (2004) *Ann. Hematol.* 83(10): 634-645). Clinical tests are also underway to evaluate antibodies or immunotoxins which target the antigens HLA-DR, CD22, CD23, CD80 in patients with CLL (Mavromatis B. H., Cheson B. D. (2004) *Blood Rev.* 18(2): 137-148; Mavromatis B., Cheson B. D. (2003) *J. Clin. Oncol.* 21(9): 1874-1881, Coleman M. et al, (2003) *Clin. Cancer Res.* 9: 3991S-3994S; Salvatore G. et al, (2002) *Clin. Cancer Res.* 8: 995-1002).

In a further embodiment, the antibody according to the invention may be used in combination with cells which express FcγRs, such as NK cells, NKT (Natural Killers T) cells, Tγδ lymphocytes, macrophages, monocytes or dendritic cells, i.e. in combination with a cellular therapy (Peller S., Kaufman S. (1991) *Blood* 78: 1569, Platsoucas C. D. et al, (1982) *J. Immunol.* 129: 2305; Kimby E. et al, (1989) *Leukaemia* 3(7): 501-504; Soorskaar D. et al, *Int. Arch. Allery Appl. Immunol.* 87(2): 159-164; Ziegler H. W. et al, (1981) *Int. J. Cancer* 27(3): 321-327; Chaperot L. et al, (2000) *Leu-*

kaemia 14(9): 1667-1677; Vuillier F., Dighiero G. (2003) *Bull. Cancer.* 90(8-9): 744-750).

In addition, the antibody according to the invention advantageously allows the doses administered to patients to be reduced: advantageously, the antibody dose administered to the patient is 2 times, 5 times, or even 10 times, 25 times, 50 times or particularly advantageously 100 times less than a dose of Rituxan®. Advantageously, the antibody dose administered to the patient is between 2 and 5 times, between 5 and 10 times, between 5 and 25 times, between 5 and 50 times, or even between 5 and 100 times less than a dose of Rituxan®. Thus, the antibody according to the invention, for instance the EMAB6 antibody, may advantageously be administered at a dose of less than 187.5 mg/m^2, 75 mg/m^2, 37.5 mg/m^2, 15 mg/m^2, 7.5 mg/m^2, or particularly advantageously less than 3.75 mg/m^2. The dose administered is advantageously between 187.5 mg/m^2 and 75 mg/m^2, or between 75 mg/m^2 and 37.5 mg/m^2, between 75 mg/m^2 and 15 mg/m^2, between 75 mg/m^2 and 7.5 mg/m^2, or even between 75 mg/m^2 and 3.75 mg/m^2.

Thus, the invention also refers to a method for treating diseases in which the target cells are cells which express CD20, such as malignant B-cell lymphoma, consisting in administering to a patient an effective dose of a composition containing an antibody according to the invention. More specifically, the treatment method is particularly suited to the treatment of leukaemia or lymphoma. Even more specifically, it is a method for treating a pathology chosen from acute B lymphoblastic leukaemia, B-cell lymphoma, mature B-cell lymphoma, including B-type Chronic Lymphocytic Leukaemia (B-CLL), small B-cell lymphoma, B-cell prolymphocytic leukaemia, lymphoplasmocytic lymphoma, mantle cell lymphoma, follicular lymphoma, marginal zone MALT-type lymphoma, lymph node marginal zone lymphoma with or without monocytoid B cells, splenic marginal zone lymphoma (with or without villous lymphocytes), tricholeucocytic leukaemia, diffuse large B-cell lymphoma, Burkitt's lymphoma, as well as any immune dysfunction diseases involving cells of the B lymphoid lines, including auto-immune diseases, consisting in administering an effective dosage of an antibody or antibody composition according to the invention.

A particular object of the invention is the use of an antibody according to the invention for the manufacture of a drug for the treatment of chronic graft-versus-host disease in order to treat symptoms which involve the receiver's B cells.

Finally, a last object of the invention is the use of an antibody according to the invention for the manufacture of a drug for a treatment of organ, in particular kidney, transplant rejection.

Recent studies (Ratanatharathorn et al, (August 2003) *Biol. Blood Marrow Transplant* 9(8): 505-511; Becker et al, (June 2004) *Am. J. Transplant.* 4(6): 996-1001) have in fact shown the benefits of anti-CD20 antibodies in the treatment of such conditions.

Further aspects and advantages of the invention will be described in the following examples which should be regarded as illustrative examples and do not limit the scope of the invention.

DESCRIPTION OF THE FIGURES

Drawings

FIG. **1**: Schematic representation of the CKHu vector used for the chimerisation of the light chain kappa of antibodies EMAB6 and EMAB603.

FIG. **2**: Schematic representation of the light chain pEF-EMAB6-K expression vector used for the production of antibody EMAB6.

FIG. **3**: Schematic representation of the G1Hu vector used for the chimerisation of the heavy chain of antibodies EMAB6 and EMAB603.

FIG. **4**: Schematic representation of the heavy chain pEF-EMAB6-H expression vector used for the production of antibody EMAB6.

FIG. **5**: Competition by the chimeric EMAB6 antibody for the binding of the murine antibody produced by CAT-13.6E12 (CAT13) to CD20 expressed on Raji cells.

FIG. **6**: Complement-dependent cytotoxic activity of the anti-CD20 antibodies on Raji cells. (A) Rituxan®: open triangle, EMAB6: closed lozenge. Cell lysis is estimated by measuring the intracellular LDH released into the supernatant. Results are expressed as percentage lysis, with 100% being the value obtained with Rituxan® (at 5,000 ng/mL anti-CD20 antibody). Mean of 5 tests. (B) Comparison of the complement-dependent cytotoxic activities of EMAB6 (closed lozenge) and EMAB603 (open lozenge).

FIG. **7**: ADCC activity induced by anti-CD20 antibodies in the presence of Raji cells. (A) Rituxan®: open triangle, EMAB6: closed lozenge. Cell lysis is estimated by measuring the intracellular LDH released into the supernatant. Results are expressed as percentage lysis, with 100% being the value obtained with Rituxan® (at 250 ng/mL anti-CD20 antibody). Mean of 3 tests. (B) Comparison of ADCC induced by EMAB6 (closed lozenge) and EMAB603 (open lozenge).

FIG. **8**: ADCC activity induced by anti-CD20 antibodies in the presence of B lymphocytes from patients with B-CLL. Rituxan®: open triangle, EMAB6: closed lozenge. E/T ratio=15. Cell lysis is estimated by measuring the calcein released into the supernatant. Results are expressed as percentages, with 100% being the value obtained with Rituxan® (at 500 ng/mL anti-CD20 antibody). Mean of 4 experiments corresponding to 4 different patients.

FIG. **9**: Activation of CD16 (FcγRIIIA) induced by anti-CD20 antibodies in the presence of Raji cells. (A) Rituxan®: open triangle, EMAB6: closed lozenge. Results are expressed as percentage of IL-2, as measured in supernatants using ELISA; with 100% being the value obtained with Rituxan® (at 2,500 ng/mL anti-CD20 antibody). Mean of 4 tests (B). Comparison between the activation of CD16 (FcγRIIIA) as induced by EMAB6 (closed lozenge) and EMAB603 (open lozenge).

FIG. **10**: Activation of CD16 (FcγRIIIA) induced by anti-CD20 antibodies in the presence of B lymphocytes from patients with B-CLL. Rituxan®: open triangle, EMAB6: closed lozenge. Results are expressed as percentage of IL-2, as measured in the supernatants using ELISA; with 100% being the value obtained with Rituxan® (at 2,500 ng/mL anti-CD20 antibody). Mean of 12 patients.

FIG. **11**: Production of IL-2 induced by the CAT-13.6E12 murine antibody in the presence of Jurkat-CD16 cells (FcγRIIIA).

FIG. **12**: Schematic representation of the heavy chain and light chain pRSV-HL-EMAB603 expression vector used for the production of antibody EMAB603.

EXAMPLES

Example 1

Construction of Expression Vectors for Anti-CD20 Chimeric Antibodies EMAB6 and EMAB603

A. Determination of the Sequence of the Variable Regions Of the CAT-13.6E12 Murine Antibody

Total RNA from murine hybridoma CAT-13.6E12 cells (supplier: DSMZ, ref. ACC 474), which produces an IgG2a, κ-type immunoglobulin, was isolated (RNAeasy kit, Qiagen ref. 74104). After reverse transcription, the variable domains of the light (Vκ) and heavy (VH) chains of the CAT-13.6E12 antibody were amplified using the 5'RACE technique (Rapid Amplification of cDNA Ends) (GeneRacer kit, Invitrogen ref. L1500-01). The primers used for the two steps were the following:

1. Reverse Transcription Primers

a. Murine Kappa specific antisense primer (SEQ ID No. 1)

5'- ACT GCC ATC AAT CTT CCA CTT GAC -3'

b. Murine G2a specific antisense primer (SEQ ID No. 2)

5'- CTG AGG GTG TAG AGG TCA GAC TG -3'

2. 5'RACE PCR Primers

a. Murine Kappa specific antisense primer (SEQ ID No. 3)

5'- TTGTTCAAGAAGCACACGACTGAGGCAC -3'

b. Murine G2a specific antisense primer (SEQ ID No. 4)

5'- GAGTTCCAGGTCAAGGTCACTGGCTCAG -3'

The resulting VH and Vκ PCR products were cloned into vector pCR4Blunt-TOPO (Zero blunt TOPO PCR cloning kit, Invitrogen, ref. K2875-20) and sequenced. The nucleotide sequence of the Vκ region of the murine CAT-13.6E12 antibody is shown as sequence SEQ ID No. 5 and the deduced peptide sequence is sequence SEQ ID No. 6. The Vκ gene belongs to the Vκ4 class [Kabat et al. (1991) "Sequences of Proteins of Immunological Interest". NIH Publication 91-3242].

The nucleotide sequence of the VH region of CAT-13.6E12 is sequence SEQ ID No. 7 and the deduced peptide sequence is sequence SEQ ID No. 8. The VH gene belongs to the VH1 class [Kabat et al. (1991) "Sequences of Proteins of Immunological Interest". NIH Publication 91-3242].

B. Construction of Heavy and Light Chain Expression Vectors for Chimeric Antibodies EMAB6 and EMAB603

1. Light Chain KAPPA Vector

1.1. Light Chain Vector for Antibody EMAB6

The Vκ sequence cloned into the pCR4Blunt-TOPO sequencing vector was amplified using the following cloning primers:

a) Vκ sense primer (SEQ ID No. 9)

5'- CTCAGTACTAGT**GCCGCCACC***ATG*GATTTTCAAGTGCAGATTTTCA G -3'

The underlined sequence corresponds to the SpeI restriction site, the sequence in bold lettering corresponds to a Kozak consensus sequence, the ATG initiator is in italics.

b) Vκ antisense primer (SEQ ID No. 10)

5'- **TGAAGACACTTGGTGCAGCCACAGT***CCGGTTTATTTCCAGCCTGG T* -3'

This primer joins the murine Vκ sequences (in italics) to the human constant region (Cκ) (in bold). The underlined sequence corresponds to the DraIII restriction site.

The resulting Vκ PCR product contains the sequence which codes for the natural signal peptide of the CAT-13.6E12 murine antibody. This Vκ PCR product was then cloned between the SpeI and DraIII sites of the light chain chimerisation vector (FIG. **1**), which corresponds to sequence SEQ ID No. 11, at 5' in the human constant region Cκ, the nucleic acid sequence of which is sequence SEQ ID No. 21 and the deduced peptide sequence of which is sequence SEQ ID No. 22. The human Cκ sequence of this chimerisation vector had been modified beforehand by silent mutagenesis in order to create a DraIII restriction site to allow cloning of murine Vκ sequences to take place. This chimerisation vector contains an RSV promoter and a bGH (bovine Growth Hormone) polyadenylation sequence together with the dhfr (dihydrofolate reductase) selection gene.

The light chain sequence of the chimeric EMAB6 antibody encoded by this vector is shown as SEQ ID No. 13 for the nucleotide sequence and corresponds to the deduced peptide sequence SEQ ID No. 14.

1.2. Light Chain Vector for Antibody EMAB603

The protocol is the same as for the light chain vector for the EMAB6 antibody (see Example 1, B-1.1), apart from the Vκ antisense primer which is:

b') Vκ antisense primer (SEQ ID No. 29)

5'-**TGAAGACACTTGGTGCAGCCACAGT**CCG□TTTATTTCCAGCCTGGT-3'

This primer joins the murine Vκ sequences (in italics) to the human constant region (Cκ) (in bold). The underlined sequence corresponds to the DraIII, restriction site.

This primer also introduces the mutation AAC→AA A(framed nucleotide in the antisense primer sequence SEQ ID No. 29), which corresponds to mutation N106K (see nucleotide sequence and deduced peptide sequence SEQ ID No. 25 and SEQ ID No. 26) relative to the natural Vκ sequence of CAT-13.6E12 (see. SEQ ID No. 5 and SEQ ID No. 6).

The light chain sequence of the chimeric EMAB603 antibody encoded by this vector is shown as SEQ ID No. 27 for the nucleotide sequence and corresponds to the deduced peptide sequence SEQ ID No. 28.

2. Heavy Chain Vector

A similar approach was applied to the chimerisation of the heavy chains of the EMAB6 and EMAB603 antibodies.

The VH sequence cloned into the pCR4Blunt-TOPO vector was first of all amplified using the following cloning primers:

a) VH sense primer (SEQ ID No. 15)

5'- CTCAGTACTAGTGCCGCCACCATGGGATTCAGCAGGATCTTTCT

C -3'

The underlined sequence corresponds to the restriction site SpeI, the sequence in bold lettering corresponds to a Kozak consensus sequence, the ATG initiator is in italics.

b) VH antisense primer (SEQ ID No. 16)

5'- GACCGATGGGCCCTTGGTGGAGGCTGAGGAGACGGTGACTGAGGTT

CC -3'

This primer joins the murine VH sequences (in italics) to the human G1 constant region (in bold). The underlined sequence corresponds to the ApaI restriction site.

The amplified VH fragment contains the sequence which codes for the natural signal peptide of the CAT-13.6E12 murine antibody. This VH PCR product was then cloned between the SpeI and ApaI sites in the heavy chain chimerisation vector (FIG. **3**) which corresponds to sequence SEQ ID No. 17, at 5' of the γ1 human constant region, the nucleic acid sequence of which is sequence SEQ ID No. 23 and the deduced peptide sequence of which is sequence SEQ ID No. 24. This chimerisation vector contains an RSV promoter and a bGH (bovine Growth Hormone) polyadenylation sequence as well as the neo selection gene.

The heavy chain sequences of the chimeric EMAB6 and EMAB603 antibodies encoded by this vector are shown as SEQ ID No. 19 for the nucleotide sequence and as SEQ ID No. 20 for the deduced peptide sequence.

3. Final Expression Vectors

3.1. EMAB6 Antibody Expression Vectors

For the expression of the EMAB6 antibody, the RSV promoter of the kappa light chain chimerisation vector (see Example 1, B-1.1) was replaced with the human EF-1 alpha promoter. The final light chain pEF-EMAB6-K expression vector is shown in FIG. **2** and corresponds to sequence SEQ ID No. 12.

The light chain sequence of the chimeric EMAB6 antibody encoded by this vector is shown as SEQ ID No. 13 for the nucleotide sequence and corresponds to the deduced peptide sequence SEQ ID No. 14.

For the expression of the EMAB6 antibody, the RSV promoter of the heavy chain chimerisation vector (see Example 1, B-2) was replaced with the human EF-1 alpha promoter. The thus-obtained final heavy chain pEF-EMAB6-H expression vector is shown in FIG. **4** and corresponds to sequence SEQ ID No. 18.

3.2. EMAB603 Antibody Expression Vector

A unique expression vector containing both heavy chain and light chain transcription units of the anti-CD20 EMAB603 antibody was constructed from two light and heavy chain chimerisation vectors (see Example 1, B-1.2 and B2 respectively) by sub-cloning into the XhoI site of the heavy chain vector, a BglII-PvuII fragment of the light chain vector containing the light chain transcription unit and the dhfr gene. This pRSV-HL-EMAB603 expression vector includes two selection genes, i.e. neo (neo-phosphotransferase II) and dhfr (dihydrofolate reductase), together with two heavy chain and light chain transcription units under the control of an RSV promoter (FIG. **12**).

Example 2

Production of Cell Lines Derived from the YB2/0 Line Producing Anti-CD20 Chimeric EMAB6 and EMAB603 Antibodies

The rat YB2/0 cell line (ATCC # CRL-1662) was cultivated in EMS medium (Invitrogen, ref. 041-95181M) containing 5% foetal calf serum (JRH Biosciences, ref. 12107). For transfection, 5 million cells were electroporated (Biorad electroporator, model 1652077) in Optimix medium (Equibio, ref. EKITE 1) with 25 μg of light chain vector pEF-EMAB6-K (FIG. **2**), linearised with AatII, and 27 μg of heavy chain vector pEF-EMAB6-H (FIG. **4**), linearised with ScaI, for the expression of the EMAB6 antibody, or with vector pRSV-HL-EMAB603, for the expression of the EMAB603 antibody. The electroporation conditions applied were 230 Volts and 960 microFarads in a 0.5-mL cuvette. Each electroporation cuvette was then distributed over 5 P96 plates at a density of 5,000 cells/well.

Placement in a selective RPMI medium (Invitrogen, ref 21875-034) containing 5% dialysed serum (Invitrogen, ref. 10603-017), 500 μg/mL G418 (Invitrogen, ref. 10131-027) and 25 nM methotrexate (Sigma, ref. M8407), was carried out 3 days after transfection.

The supernatants from the resistant transfection wells were screened for the presence of chimeric immunoglobulin (Ig) by applying an ELISA assay specific to the human Ig sequences.

The 10 transfectants producing the largest amount of antibody were amplified on P24 plates and their supernatants re-assayed using ELISA to estimate their productivity and select, by limited dilution (40 cells/plate), the best three producers for cloning.

After cloning, the R509.6A4 clone (R509-33903/046-6H1 $(1)_6$A4, productivity: 17 μg/10^6 cells), hereafter referred to as "R509", as well as the R603 clone were selected for the production of the chimeric EMAB6 and EMAB603 antibodies respectively and progressively acclimated to the CD Hybridoma production medium (Invitrogen, ref. 11279-023).

The production of the chimeric EMAB6 and EMAB603 antibodies was achieved by expanding, in CD Hybridoma medium, the acclimated culture obtained by dilution to 3×10^5 cells/mL in 75-cm^2 and 175-cm^2 vials and then dilution to 4.5×10^5 cells/mL in roller flasks. Once the maximum volume (1 L) was achieved, culture was continued until the cell viability was only 20%. After production, the chimeric EMAB6 and EMAB603 antibodies were purified using protein-A affinity chromatography (HPLC estimated purity <95%) and checked by polyacrylamide gel electrophoresis.

Example 3

Characterisation of the Functional Activity of Chimeric Antibodies EMAB6 and EMAB603

A. Specificity

Specificity of the antigen recognition of the chimeric EMAB6 antibody was evaluated by studying the competition with the murine antibody CAT-13.6E12 (CAT13) for binding the CD20 antigen expressed by Raji cells.

For that purpose, the EMAB6 antibody (10 μL at 0.5 to 50 μg/mL) was incubated at 4° C. with a fixed quantity of CAT-13.6E12 murine antibody (10 μL at 5 μg/mL) for 20 minutes in the presence of Raji cells (50 μL at 4×10^6 cells/mL). After washing, a mouse anti-IgG antibody coupled to phycoerythrin (PE) was added to the Raji cells so as to specifically detect

the binding of the CAT-13.6E12 murine antibody. The Median Fluorescence Intensities (MFIs) obtained in the presence of various concentrations of EMAB6 are converted to percentages, with 100% corresponding to binding to CAT-13.6E12 cells in the absence of the EMAB6 antibody.

An inhibition curve is thus obtained for binding of the CAT-13.6E12 (CAT13) antibody to Raji cells in the presence of increasing concentrations of EMAB6 (FIG. **5**).

This study demonstrates that the chimerisation process has not adversely affected the specificity of the EMAB6 antibody, which does compete with the parental CAT-13.6E12 murine antibody for binding to CD20 expressed on the surface of Raji cells.

The antigen recognition specificity of the EMAB603 antibody is comparable with that of the EMAB6 antibody.

B. Complement-Dependent Cytotoxic Activity

Complement-dependent cytotoxic activity of the EMAB6 and EMAB603 antibodies was examined with Raji cells in the presence of young rabbit serum as a source of complement; the anti-CD20 chimeric antibody Rituxan® was included in one test, for comparison.

For this test, the Raji cells were adjusted to 6×10^5 cells/mL in IMDM (Iscove's Modified Dulbecco's Medium) 5% FCS (Foetal Calf Serum). The antibodies were diluted with IMDM+0.5% FCS. The reaction mixture was made up of 50 μL antibody, 50 μL young rabbit serum (1/10 IMDM+0.5% FCS dilution of Cedarlane CL 3441 reagent), 50 μL target cells and 50 μL IMDM+0.5% FCS medium. The final antibody concentrations were 5,000, 1,250, 250 and 50 ng/mL. A control without antibodies was included in the test. After 1 hr incubation at 37° C. in a 5% CO_2 atmosphere, the plates were centrifuged and the levels of intracellular LDH released into the supernatant estimated using a specific reagent (Cytotoxicity Detection Kit 1 644 793).

The percentage lysis was estimated using a calibration range obtained using various dilutions of target cells lysed using triton X100 (2%) corresponding to 100, 50, 25, and 0% lysis respectively.

The results shown in FIG. **6**(A) demonstrate that EMAB6 and Rituxan® both induce complement-dependent lysis of the Raji cells. Nevertheless, EMAB6 complement activity appeared to be slightly less than that of Rituxan®. This difference is greater at the low concentrations of antibody used in this test. Thus for concentrations of 50 and 250 ng/mL, the activity of EMAB6 is of the order of 45% of that of Rituxan®. This difference becomes smaller as the antibody concentration is increased, with the % complement-dependent cytotoxic activity of the EMAB6 antibody representing 92% of that of Rituxan® at the highest concentration tested, i.e. 5,000 ng/mL.

This lower complement-dependent cytotoxic activity of the AMAB6 antibody compared to that of Rituxan® may be regarded as an advantage, since it limits the potential in vivo toxicity of EMAB6 compared to Rituxan®, associated with the activation of the conventional complement pathway, which leads to the production of various molecules with undesirable inflammatory, allergic and vascular activities.

The complement activity of the EMAB603 antibody is shown in FIG. **6**(B).

C. ADCC Activity

The cytotoxicity of the chimeric EMAB6 antibody was evaluated in the presence of Raji cells or B lymphocytes from patients with CLL. The anti-CD20 chimeric antibody Rituxan® was included in the tests for comparison.

The calcein-labelling ADCC measurement technique used was as follows:

NK cells were isolated from PBMCs using the separation on magnetic beads (MACS) technique from Myltenyi. The cells were washed and re-suspended in IMDM+5% FCS (45×10^5 cells/mL). The effector cells and target cells were used in a ratio of 15/1. The Raji cells or the PBMCs (Peripheral Blood Mononuclear Cells) from patients with B-CLL obtained after Ficoll treatment (>95% B cells) were labelled beforehand with calcein (1 mL cells at 3×10^6 cells/mL in IMDM+5% FCS+20 μL calcein (20 μM), 20 min incubation at 37° C. and then washing with HBSS (Hank's Buffered Saline Solution)) and adjusted to 3×10^5 cells/mL in IMDM+5% FCS. The antibodies were diluted with IMDM+0.5% FCS (final concentrations: 500; 50; 5; 0.5; 0.05 and 0.005 ng/mL).

The reaction mixture was made up of 50 μL antibody, 50 μL effector cells, 50 μL target cells and 50 μL IMDM medium in a P96 microtitration plate. Two negative controls were used:

- Lysis without NK: NK effector cells were replaced with IMDM+5% FCS.
- Lysis without antibodies (Ab): antibodies were replaced with IMDM+5% FCS.

After 4 hrs incubation at 37° C. in a 5% CO_2 atmosphere, the plates were centrifuged and the fluorescence associated with the supernatant was measured using a fluorimeter (excitation: 485 nm, emission: 535 nm).

The percentage lysis was estimated using a calibration range obtained using various dilutions of target cells lysed using Triton X100 (2%), corresponding to 100, 50, 25, and 0% lysis respectively.

The results were first calculated using the following formula:

$$\%\ \text{lysis}=(\%\ \text{lysis with Antibody and NK})-(\%\ \text{lysis without Antibody})-(\%\ \text{lysis without NK})$$

and then expressed as relative percentages, with 100% being the value obtained at the highest concentration of Rituxan®.

The results obtained for the EMAB6 antibody on the Raji line cells shown in FIG. **7**(A) demonstrate that, irrespective of the concentration being tested, the cytotoxicity induced by the EMAB6 antibody is greater than that induced by Rituxan®. This difference is particularly large at low antibody concentrations. Thus, at 0.5 ng/mL, the lysis percentages were 96% and 4% for EMAB6 and Rituxan® respectively. By increasing the dose 500-fold (250 ng/mL), the difference is still appreciable since the relative percentages of ADCC are 164% and 100% for EMAB6 and Rituxan® respectively. When the EC50s were calculated (antibody concentration corresponding to 50% of the E Max, the maximum effectiveness obtained at the highest antibody concentration and at the plateau) by graphical estimation (in ng/mL) and assuming that Rituxan® and EMAB6 attain the same E Max, the Rituxan® EC50/EMAB6 EC50 ratio in this test was then equal to 300.

The cytotoxicity of the chimeric EMAB603 antibody was evaluated in the presence of Raji cells using the same procedure as for the EMAB6 antibodies. Its activity was comparable with that of the EMAB6 antibody (see FIG. **7**(B)).

With the lymphocytes from patients with B-CLL, the results obtained, shown in FIG. **8**, demonstrate that, irrespective of the concentration being tested, the cytotoxicity induced by the EMAB6 antibody is greater than that induced by Rituxan®. As already observed with the Raji cells, this difference is particularly large at low antibody concentrations. A concentration of 0.5 ng/mL EMAB6 induces the same percentage lysis as 500 ng/mL Rituxan®, i.e. a concentration ratio of 1,000. At 5 ng/mL, the lysis percentages are 269% and 9% for EMAB6 and Rituxan® respectively. At the maximum dose tested (500 ng/mL), the difference is still very

large since the relative percentages of ADCC are 350% and 100% for EMAB6 and Rituxan® respectively. An interesting result corresponds to the concentrations which give rise to 50% lysis. In this test, the Rituxan® EC50/EMAB6 EC50 ratio was estimated as 10,000 (graphical estimate in ng/mL for EC50 assuming that Rituxan® and EMAB6 attain the same E Max).

In these tests, the cytotoxic activities of EMAB6 and EMAB603 are therefore much greater than that of Rituxan®.

D. Activation of CD16 (IL-2 Secretion)

The activation of CD16 (FcγRIIIA) induced by the chimeric EMAB6 antibody was determined in the presence of Raji cells or B lymphocytes from patients with CLL. This test evaluated the ability of the antibody to bind to CD16 (FcγRIIIA) receptor expressed on the Jurkat-CD16 cells and to induce the secretion of IL-2. The anti-CD20 chimeric antibody Rituxan® is included in the tests for comparison.

Measurement of CD16 activation was carried out in the following manner on the Jurkat-CD16 cell line in the presence of Raji cells or B lymphocytes from patients with CLL.

Mixture in 96-well plate: 50 μL antibody solution (dilution to 10,000, 1,000, 100 and 10 ng/mL with IMDM+5% FCS for B lymphocytes from patients with B-CLL and 10,000, 2,000, 1,000, 200, 100, 50 and 25 ng/mL for Raji cells), 50 μL PMA (Phorbol Myristate Acetate, diluted to 40 ng/mL with IMDM+5% FCS), 50 μL Raji or PBMCs from patients with B-CLL obtained after Ficoll treatment (>95% B cells) diluted to 6×10^5/mL with IMDM+5% FCS, and 50 μL Jurkat-CD16 cells (20×10^6/mL in IMDM+5% FCS). Controls without antibodies were included in all tests. After incubation overnight at 37° C., the plates were centrifuged and the IL-2 contained in the supernatants estimated using a commercial kit (Quantikine from R/D). The OD readings were made at 450 nm.

The results were initially expressed as IL-2 levels as a function of the antibody concentration (from 0 to 250 ng/mL final concentration), then as relative percentages, where 100% is the value obtained with Rituxan® at the highest test concentration.

The results obtained with the Raji line cells shown in FIG. **9**(A) demonstrate that, in the presence of EMAB6 and Rituxan®, the Jurkat-CD16 cells secrete IL-2, which indicates cell activation via binding of the Fc portion of the antibodies to CD16. The EMAB6 antibody, however, has an inductive activity which is much stronger than the Rituxan® antibody. Thus, at 6.25 ng/mL, the IL-2 percentages were 112% and 21% for EMAB6 and Rituxan® respectively. At 50 ng/mL, the difference is still large, with the percentages of IL-2 being 112% and 65% respectively. This difference decreases as concentration increases, with the respective percentages of IL-2 for EMAB6 and Rituxan® being 124% and 100% at 2,500 ng/mL. In this test, the Rituxan® EC50/EMAB6 EC50 ratio is estimated at 15 (graphical estimate in ng/mL for EC50 assuming that Rituxan® and EMAB6 attain the same E Max).

These results confirm the ADCC results, both being CD16-dependant. They demonstrate that the binding to CD16 (FcγRIIIA) by the Fc portion of the EMAB6 antibody is followed by a strong cellular activation which leads to the induction of effector functions.

The activation of CD16 (FcγRIIIA) induced by the chimeric EMAB603 antibody in the presence of Raji cells is comparable with that induced by the EMAB6 antibody.

With lymphocytes from patients with B-CLL, the results obtained shown in FIG. **10** demonstrate that in the presence of anti-CD20 Rituxan® and EMAB6, the Jurkat-CD16 cells secrete IL-2, which indicates cell activation via binding of the Fc portion of the antibodies to CD16. The EMAB6 antibody, however, has an inductive ability which is much greater than the Rituxan® antibody. In fact, the IL-2 secretion induction activity of Rituxan® is close to the base line at concentrations of 2.5 and 25 ng/mL, whereas that of the EMAB6 antibody is significant. Thus at 25 ng/mL, the IL-2 percentages were 132% and 34% for EMAB6 and Rituxan® respectively. At the highest concentration (2,500 ng/mL), the IL-2 percentages were 148% and 100% respectively. The Rituxan® EC50/EMAB6 EC50 ratio in this test is greater than 100: it is estimated at 300 (graphical estimate in ng/mL for EC50 assuming that Rituxan® and EMAB6 attain the same E Max).

In conclusion, all the tests carried out on Raji cells demonstrate that the EMAB6 and EMAB603 antibodies, unlike Rituxan®, are highly cytotoxic and induce the activation of cells which express CD16 (FcγRIIIA), especially at low antibody concentrations. On the contrary, under the same conditions, the complement-dependent cytotoxic activity of EMAB6 decreases by about 50% compared to that of Rituxan®.

These results are confirmed by the studies carried out using cells isolated from patients with B-CLL, suggesting that the EMAB6 antibody is much more cytotoxic than Rituxan® towards B lymphocytes from patients with B-CLL. The differences between the two antibodies are more marked with lymphocytes from patients with B-CLL than with the Raji cells, which demonstrates the significant therapeutic interest of EMAB6 compared to Rituxan® for this condition.

The reason of this increased difference may be, amongst other, the lower antigen expression of CD20 on B lymphocytes from patients with B-CLL compared to Raji cells.

By analogy with Raji cells, it may be suggested that the complement-dependent cytotoxic activity of the EMAB6 antibody towards lymphocytes from patients with B-CLL must be less than that induced by Rituxan®, thus exhibiting the advantage of being less toxic in vivo as a result of the undesirable effects associated with a strong activation of the conventional complement pathway.

Example 4

Analysis of EMAB6 and EMAB603 Glycans by HPCE-LIF

The N-glycan structure of the heavy chains of the EMAB6 and EMAB603 antibodies was analysed using HPCE-LIF. The N-glycan structure of the heavy chain of Rituxan® was also analysed for comparison.

For that purpose, anti-CD20 monoclonal antibodies were desalted on a Sephadex G-25 column (HiTrap Desalting, Amersham Biosciences), evaporated and re-suspended in the hydrolysis buffer of PNGase F (Glyko) in the presence of 50 mM β-mercaptoethanol. After 16 hrs incubation at 37° C., the protein fraction was precipitated by adding absolute ethanol and the supernatant, which contained the N-glycans, was evaporated. The resulting oligosaccharides were either directly labelled using a fluorochrome: APTS (1-aminopyrene-3,6,8-trisulphonate), or subjected to the action of specific exoglycosidases before labelling with APTS. The resulting labelled oligosaccharides were injected onto an N—CHO capillary, separated and quantified by capillary electrophoresis with laser-induced fluorescence detection (HPCE-LIF).

The estimation of the fucose level was carried out either by the addition of the isolated fucosylated forms, or more specifically after the simultaneous action of neuraminidase, β-galactosidase and N-acetylhexosaminidase, which resulted

in 2 peaks corresponding to the fucosylated or non-fucosylated pentasaccharide [GlcNac2-Man3] being obtained on the electrophoretogram:

TABLE 1

Analysis of anti-CD20 EMAB603 and Rituxan ® N-glycans

Anti-CD20	% Fucose	% Galactose	Fuc/Gal
EMAB603	15	37	0.4
Rituxan ®	93	57	1.63

The fucose level, expressed as %, was calculated using the following formula:

$$\text{Fucose level} = \frac{\text{fucosylated } [GlcNac2 - Man3] \times 100}{[GlcNac2 - Man3 + \text{fucosylated } GlcNac2 - Man3]}$$

The galactose level, expressed as %, was calculated by adding the percentages of the oligosaccharide forms containing galactose obtained after the action of neuraminidase and fucosidase. The formula used is as follows:

$$\text{Galactose level} = (G1 + G1B) + 2 \times (G2 + G2B)$$

The fucose/galactose ratio is obtained by dividing the fucose level by the galactose level, calculated as described above.

From this analysis (see Table 1), it appears that the EMAB6 and EMAB603 antibodies are little fucosylated (% fucose <25%) compared to Rituxan® (% fucose=93%). In addition, the Fuc/Gal ratio (fucose/galactose ratio) for EMAB6 and EMAB603 is low (Fuc/Gal ratio<0.6), unlike the antibodies expressed in CHO cells such as Rituxan® (Fuc/Gal ratio=1.63).

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<400> SEQUENCE: 6

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Glu Lys Val Thr Met Thr Cys Arg Ala Ser Ser Ser Val Ser Tyr Met
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35 40 45

Ala Thr Ser Asn Leu Ala Ser Gly Val Pro Ala Arg Phe Ser Gly Ser
50 55 60

Gly Ser Gly Thr Ser Tyr Ser Phe Thr Ile Ser Arg Val Glu Ala Glu
65 70 75 80

Asp Ala Ala Thr Tyr Tyr Cys Gln Gln Trp Thr Phe Asn Pro Pro Thr
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Phe Gly Gly Gly Thr Arg Leu Glu Ile Asn Arg
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<210> SEQ ID NO 7
<211> LENGTH: 354
<212> TYPE: DNA
<213> ORGANISM: Mus musculus

<400> SEQUENCE: 7

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<210> SEQ ID NO 8
<211> LENGTH: 118
<212> TYPE: PRT
<213> ORGANISM: Mus musculus

<400> SEQUENCE: 8

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Gly Gly Ile Tyr Pro Gly Asn Gly Asp Thr Ser Tyr Asn Gln Lys Phe
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Lys Gly Lys Ala Thr Leu Thr Val Gly Lys Ser Ser Ser Thr Ala Tyr
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Met Gln Leu Ser Ser Leu Thr Ser Glu Asp Ser Ala Val Tyr Phe Cys
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<212> TYPE: DNA
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<220> FEATURE:
<223> OTHER INFORMATION: Primer

<400> SEQUENCE: 9

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<210> SEQ ID NO 10
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<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Primer

<400> SEQUENCE: 10

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<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Vector

<400> SEQUENCE: 11

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<211> LENGTH: 6275
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:

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<223> OTHER INFORMATION: Vector

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<210> SEQ ID NO 13
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<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Synthetic Construct

<400> SEQUENCE: 13

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<210> SEQ ID NO 14
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<212> TYPE: PRT
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Synthetic Construct

<400> SEQUENCE: 14

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Glu Lys Val Thr Met Thr Cys Arg Ala Ser Ser Ser Val Ser Tyr Met
20 25 30

His Trp Tyr Gln Gln Lys Pro Gly Ser Ser Pro Lys Pro Trp Ile Tyr
35 40 45

Ala Thr Ser Asn Leu Ala Ser Gly Val Pro Ala Arg Phe Ser Gly Ser
50 55 60

Gly Ser Gly Thr Ser Tyr Ser Phe Thr Ile Ser Arg Val Glu Ala Glu
65 70 75 80

Asp Ala Ala Thr Tyr Tyr Cys Gln Gln Trp Thr Phe Asn Pro Pro Thr
85 90 95

Phe Gly Gly Gly Thr Arg Leu Glu Ile Asn Arg Thr Val Ala Ala Pro
100 105 110

Ser Val Phe Ile Phe Pro Pro Ser Asp Glu Gln Leu Lys Ser Gly Thr
115 120 125

Ala Ser Val Val Cys Leu Leu Asn Asn Phe Tyr Pro Arg Glu Ala Lys
130 135 140

Val Gln Trp Lys Val Asp Asn Ala Leu Gln Ser Gly Asn Ser Gln Glu
145 150 155 160

Ser Val Thr Glu Gln Asp Ser Lys Asp Ser Thr Tyr Ser Leu Ser Ser
165 170 175

Thr Leu Thr Leu Ser Lys Ala Asp Tyr Glu Lys His Lys Val Tyr Ala
180 185 190

Cys Glu Val Thr His Gln Gly Leu Ser Ser Pro Val Thr Lys Ser Phe
195 200 205

Asn Arg Gly Glu Cys
210

<210> SEQ ID NO 15
<211> LENGTH: 45
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Primer

<400> SEQUENCE: 15

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<210> SEQ ID NO 16
<211> LENGTH: 48
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:

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<223> OTHER INFORMATION: Primer

<400> SEQUENCE: 16

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<210> SEQ ID NO 17
<211> LENGTH: 5739
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Vector

<400> SEQUENCE: 17

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<210> SEQ ID NO 18
<211> LENGTH: 6824
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Vector

<400> SEQUENCE: 18

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gataggtgcc tcactgatta agcattggta actgtcagac caagtttact catatatact 6000

ttagattgat ttaaaacttc atttttaatt taaaaggatc taggtgaaga tccttttttga 6060

taatctcatg accaaaatcc cttaacgtga gttttcgttc cactgagcgt cagaccccgt 6120

agaaaagatc aaaggatctt cttgagatcc ttttttttctg cgcgtaatct gctgcttgca 6180

aacaaaaaaa ccaccgctac cagcggtggt ttgtttgccg gatcaagagc taccaactct 6240

ttttccgaag gtaactggct tcagcagagc gcagatacca aatactgtcc ttctagtgta 6300

gccgtagtta ggccaccact tcaagaactc tgtagcaccg cctacatacc tcgctctgct 6360

aatcctgtta ccagtggctg ctgccagtgg cgataagtcg tgtcttaccg ggttggactc 6420

aagacgatag ttaccggata aggcgcagcg gtcgggctga acgggggggtt cgtgcacaca 6480

gcccagcttg gagcgaacga cctacaccga actgagatac ctacagcgtg agctatgaga 6540

aagcgccacg cttcccgaag ggagaaaggc ggacaggtat ccggtaagcg gcagggtcgg 6600

aacaggagag cgcacgaggg agcttccagg gggaaacgcc tggtatcttt atagtcctgt 6660

cgggtttcgc cacctctgac ttgagcgtcg atttttgtga tgctcgtcag gggggcggag 6720

cctatggaaa aacgccagca acgcggcctt tttacggttc ctggcctttt gctggccttt 6780

tgctcacatg gctcgacaga tccgacggat cgggagatcc tagc 6824

<210> SEQ ID NO 19
<211> LENGTH: 1344
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Synthetic Construct

<400> SEQUENCE: 19

caggcttatc tacagcagtc tggggctgag ctggtgaggc ctggggcctc agtgaagatg 60

tcctgcaagg cttctggcta cacatttacc agttacaata tgcactgggt aaagcagaca 120

cctagacagg gcctggaatg gattggaggt atttatccag gaaatggtga tacttcctac 180

aatcagaagt tcaagggcaa ggccacactg actgtaggca aatcctccag cacagcctac 240

atgcagctca gcagcctgac atctgaagac tctgcggtct atttctgtgc aagatatgac 300

tacaactatg ctatggacta ctggggtcaa ggaacctcag tcaccgtctc ctcagcctcc 360

accaagggcc catcggtctt cccctggca ccctcctcca agagcacctc tgggggcaca 420

gcggccctgg gctgcctggt caaggactac ttccccgaac cggtgacggt gtcgtggaac 480

tcaggcgccc tgaccagcgg cgtgcacacc ttcccggctg tcctacagtc ctcaggactc 540

-continued

```
tactccctca gcagcgtggt gaccgtgccc tccagcagct tgggcaccca gacctacatc    600

tgcaacgtga atcacaagcc cagcaacacc aaggtggaca agaaagttga gcccaaatct    660

tgtgacaaaa ctcacacatg cccaccgtgc ccagcacctg aactcctggg gggaccgtca    720

gtcttcctct tccccccaaa acccaaggac accctcatga tctcccggac ccctgaggtc    780

acatgcgtgg tggtggacgt gagccacgaa gaccctgagg tcaagttcaa ctggtacgtg    840

gacggcgtgg aggtgcataa tgccaagaca aagccgcggg aggagcagta caacagcacg    900

taccgtgtgg tcagcgtcct caccgtcctg caccaggact ggctgaatgg caaggagtac    960

aagtgcaagg tctccaacaa agccctccca gcccccatcg agaaaaccat ctccaaagcc   1020

aaagggcagc cccgagaacc acaggtgtac accctgcccc catcccggga tgagctgacc   1080

aagaaccagg tcagcctgac ctgcctggtc aaaggcttct atcccagcga catcgccgtg   1140

gagtgggaga gcaatgggca gccggagaac aactacaaga ccacgcctcc cgtgctggac   1200

tccgacggct ccttcttcct ctacagcaag ctcaccgtgg acaagagcag gtggcagcag   1260

gggaacgtct tctcatgctc cgtgatgcat gaggctctgc acaaccacta cacgcagaag   1320

agcctctccc tgtctccggg taaa                                          1344
```

<210> SEQ ID NO 20
<211> LENGTH: 448
<212> TYPE: PRT
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Synthetic Construct

<400> SEQUENCE: 20

```
Gln Ala Tyr Leu Gln Gln Ser Gly Ala Glu Leu Val Arg Pro Gly Ala
1               5                  10                  15

Ser Val Lys Met Ser Cys Lys Ala Ser Gly Tyr Thr Phe Thr Ser Tyr
            20                  25                  30

Asn Met His Trp Val Lys Gln Thr Pro Arg Gln Gly Leu Glu Trp Ile
        35                  40                  45

Gly Gly Ile Tyr Pro Gly Asn Gly Asp Thr Ser Tyr Asn Gln Lys Phe
    50                  55                  60

Lys Gly Lys Ala Thr Leu Thr Val Gly Lys Ser Ser Ser Thr Ala Tyr
65                  70                  75                  80

Met Gln Leu Ser Ser Leu Thr Ser Glu Asp Ser Ala Val Tyr Phe Cys
                85                  90                  95

Ala Arg Tyr Asp Tyr Asn Tyr Ala Met Asp Tyr Trp Gly Gln Gly Thr
            100                 105                 110

Ser Val Thr Val Ser Ser Ala Ser Thr Lys Gly Pro Ser Val Phe Pro
        115                 120                 125

Leu Ala Pro Ser Ser Lys Ser Thr Ser Gly Gly Thr Ala Ala Leu Gly
    130                 135                 140

Cys Leu Val Lys Asp Tyr Phe Pro Glu Pro Val Thr Val Ser Trp Asn
145                 150                 155                 160

Ser Gly Ala Leu Thr Ser Gly Val His Thr Phe Pro Ala Val Leu Gln
                165                 170                 175

Ser Ser Gly Leu Tyr Ser Leu Ser Ser Val Val Thr Val Pro Ser Ser
            180                 185                 190

Ser Leu Gly Thr Gln Thr Tyr Ile Cys Asn Val Asn His Lys Pro Ser
        195                 200                 205

Asn Thr Lys Val Asp Lys Lys Val Glu Pro Lys Ser Cys Asp Lys Thr
    210                 215                 220
```

-continued

```
His Thr Cys Pro Pro Cys Pro Ala Pro Glu Leu Leu Gly Gly Pro Ser
225                 230                 235                 240

Val Phe Leu Phe Pro Pro Lys Pro Lys Asp Thr Leu Met Ile Ser Arg
                245                 250                 255

Thr Pro Glu Val Thr Cys Val Val Val Asp Val Ser His Glu Asp Pro
            260                 265                 270

Glu Val Lys Phe Asn Trp Tyr Val Asp Gly Val Glu Val His Asn Ala
        275                 280                 285

Lys Thr Lys Pro Arg Glu Glu Gln Tyr Asn Ser Thr Tyr Arg Val Val
    290                 295                 300

Ser Val Leu Thr Val Leu His Gln Asp Trp Leu Asn Gly Lys Glu Tyr
305                 310                 315                 320

Lys Cys Lys Val Ser Asn Lys Ala Leu Pro Ala Pro Ile Glu Lys Thr
                325                 330                 335

Ile Ser Lys Ala Lys Gly Gln Pro Arg Glu Pro Gln Val Tyr Thr Leu
            340                 345                 350

Pro Pro Ser Arg Asp Glu Leu Thr Lys Asn Gln Val Ser Leu Thr Cys
        355                 360                 365

Leu Val Lys Gly Phe Tyr Pro Ser Asp Ile Ala Val Glu Trp Glu Ser
    370                 375                 380

Asn Gly Gln Pro Glu Asn Asn Tyr Lys Thr Thr Pro Pro Val Leu Asp
385                 390                 395                 400

Ser Asp Gly Ser Phe Phe Leu Tyr Ser Lys Leu Thr Val Asp Lys Ser
                405                 410                 415

Arg Trp Gln Gln Gly Asn Val Phe Ser Cys Ser Val Met His Glu Ala
            420                 425                 430

Leu His Asn His Tyr Thr Gln Lys Ser Leu Ser Leu Ser Pro Gly Lys
        435                 440                 445


<210> SEQ ID NO 21
<211> LENGTH: 318
<212> TYPE: DNA
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 21

actgtggctg caccaagtgt cttcatcttc ccgccatctg atgagcagtt gaaatctgga     60

actgcctctg ttgtgtgcct gctgaataac ttctatccca gagaggccaa agtacagtgg    120

aaggtggata acgccctcca atcgggtaac tcccaggaga gtgtcacaga gcaggacagc    180

aaggacagca cctacagcct cagcagcacc ctgacgctga gcaaagcaga ctacgagaaa    240

cacaaagtct acgcctgcga agtcacccat cagggcctga gctcgcccgt cacaaagagc    300

ttcaacaggg gagagtgt                                                  318


<210> SEQ ID NO 22
<211> LENGTH: 106
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 22

Thr Val Ala Ala Pro Ser Val Phe Ile Phe Pro Pro Ser Asp Glu Gln
1               5                   10                  15

Leu Lys Ser Gly Thr Ala Ser Val Val Cys Leu Leu Asn Asn Phe Tyr
            20                  25                  30

Pro Arg Glu Ala Lys Val Gln Trp Lys Val Asp Asn Ala Leu Gln Ser
        35                  40                  45
```

-continued

```
Gly Asn Ser Gln Glu Ser Val Thr Glu Gln Asp Ser Lys Asp Ser Thr
    50                  55                  60

Tyr Ser Leu Ser Ser Thr Leu Thr Leu Ser Lys Ala Asp Tyr Glu Lys
65                  70                  75                  80

His Lys Val Tyr Ala Cys Glu Val Thr His Gln Gly Leu Ser Ser Pro
                85                  90                  95

Val Thr Lys Ser Phe Asn Arg Gly Glu Cys
            100                 105
```

<210> SEQ ID NO 23
<211> LENGTH: 990
<212> TYPE: DNA
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 23

```
gcctccacca agggcccatc ggtcttcccc ctggcaccct cctccaagag cacctctggg     60

ggcacagcgg ccctgggctg cctggtcaag gactacttcc ccgaaccggt gacggtgtcg    120

tggaactcag gcgccctgac cagcggcgtg cacaccttcc cggctgtcct acagtcctca    180

ggactctact ccctcagcag cgtggtgacc gtgccctcca gcagcttggg cacccagacc    240

tacatctgca acgtgaatca caagcccagc aacaccaagg tggacaagaa agttgagccc    300

aaatcttgtg acaaaactca cacatgccca ccgtgcccag cacctgaact cctgggggga    360

ccgtcagtct tcctcttccc cccaaaaccc aaggacaccc tcatgatctc ccggacccct    420

gaggtcacat gcgtggtggt ggacgtgagc cacgaagacc ctgaggtcaa gttcaactgg    480

tacgtggacg gcgtggaggt gcataatgcc aagacaaagc cgcgggagga gcagtacaac    540

agcacgtacc gtgtggtcag cgtcctcacc gtcctgcacc aggactggct gaatggcaag    600

gagtacaagt gcaaggtctc caacaaagcc ctcccagccc ccatcgagaa aaccatctcc    660

aaagccaaag ggcagccccg agaaccacag gtgtacaccc tgcccccatc ccgggatgag    720

ctgaccaaga accaggtcag cctgacctgc ctggtcaaag gcttctatcc cagcgacatc    780

gccgtggagt gggagagcaa tgggcagccg gagaacaact acaagaccac gcctcccgtg    840

ctggactccg acggctcctt cttcctctac agcaagctca ccgtggacaa gagcaggtgg    900

cagcagggga acgtcttctc atgctccgtg atgcatgagg ctctgcacaa ccactacacg    960

cagaagagcc tctccctgtc tccgggtaaa                                     990
```

<210> SEQ ID NO 24
<211> LENGTH: 330
<212> TYPE: PRT
<213> ORGANISM: Homo sapiens

<400> SEQUENCE: 24

```
Ala Ser Thr Lys Gly Pro Ser Val Phe Pro Leu Ala Pro Ser Ser Lys
1               5                   10                  15

Ser Thr Ser Gly Gly Thr Ala Ala Leu Gly Cys Leu Val Lys Asp Tyr
            20                  25                  30

Phe Pro Glu Pro Val Thr Val Ser Trp Asn Ser Gly Ala Leu Thr Ser
        35                  40                  45

Gly Val His Thr Phe Pro Ala Val Leu Gln Ser Ser Gly Leu Tyr Ser
    50                  55                  60

Leu Ser Ser Val Val Thr Val Pro Ser Ser Ser Leu Gly Thr Gln Thr
65                  70                  75                  80

Tyr Ile Cys Asn Val Asn His Lys Pro Ser Asn Thr Lys Val Asp Lys
```

-continued

```
                85                  90                  95

Lys Val Glu Pro Lys Ser Cys Asp Lys Thr His Thr Cys Pro Pro Cys
            100                 105                 110

Pro Ala Pro Glu Leu Leu Gly Gly Pro Ser Val Phe Leu Phe Pro Pro
        115                 120                 125

Lys Pro Lys Asp Thr Leu Met Ile Ser Arg Thr Pro Glu Val Thr Cys
    130                 135                 140

Val Val Val Asp Val Ser His Glu Asp Pro Glu Val Lys Phe Asn Trp
145                 150                 155                 160

Tyr Val Asp Gly Val Glu Val His Asn Ala Lys Thr Lys Pro Arg Glu
                165                 170                 175

Glu Gln Tyr Asn Ser Thr Tyr Arg Val Val Ser Val Leu Thr Val Leu
            180                 185                 190

His Gln Asp Trp Leu Asn Gly Lys Glu Tyr Lys Cys Lys Val Ser Asn
        195                 200                 205

Lys Ala Leu Pro Ala Pro Ile Glu Lys Thr Ile Ser Lys Ala Lys Gly
    210                 215                 220

Gln Pro Arg Glu Pro Gln Val Tyr Thr Leu Pro Pro Ser Arg Asp Glu
225                 230                 235                 240

Leu Thr Lys Asn Gln Val Ser Leu Thr Cys Leu Val Lys Gly Phe Tyr
                245                 250                 255

Pro Ser Asp Ile Ala Val Glu Trp Glu Ser Asn Gly Gln Pro Glu Asn
            260                 265                 270

Asn Tyr Lys Thr Thr Pro Pro Val Leu Asp Ser Asp Gly Ser Phe Phe
        275                 280                 285

Leu Tyr Ser Lys Leu Thr Val Asp Lys Ser Arg Trp Gln Gln Gly Asn
    290                 295                 300

Val Phe Ser Cys Ser Val Met His Glu Ala Leu His Asn His Tyr Thr
305                 310                 315                 320

Gln Lys Ser Leu Ser Leu Ser Pro Gly Lys
                325                 330


<210> SEQ ID NO 25
<211> LENGTH: 321
<212> TYPE: DNA
<213> ORGANISM: Mus musculus

<400> SEQUENCE: 25

caaattgttc tctcccagtc tccagcaatc ctgtctgcat ctccagggga gaaggtcaca     60

atgacttgca gggccagctc aagtgtaagt tacatgcact ggtaccagca gaagccagga    120

tcctccccca aaccctggat ttatgccaca tccaacctgg cttctggagt ccctgctcgc    180

ttcagtggca gtgggtctgg gacctcttat tctttcacaa tcagcagagt ggaggctgaa    240

gatgctgcca cttattactg ccagcagtgg acttttaacc cacccacgtt cggaggggggg    300

accaggctgg aaataaaacg g                                              321


<210> SEQ ID NO 26
<211> LENGTH: 107
<212> TYPE: PRT
<213> ORGANISM: Mus musculus

<400> SEQUENCE: 26

Gln Ile Val Leu Ser Gln Ser Pro Ala Ile Leu Ser Ala Ser Pro Gly
1               5                   10                  15

Glu Lys Val Thr Met Thr Cys Arg Ala Ser Ser Ser Val Ser Tyr Met
```

-continued

```
            20                  25                  30

His Trp Tyr Gln Gln Lys Pro Gly Ser Ser Pro Lys Pro Trp Ile Tyr
        35                  40                  45

Ala Thr Ser Asn Leu Ala Ser Gly Val Pro Ala Arg Phe Ser Gly Ser
    50                  55                  60

Gly Ser Gly Thr Ser Tyr Ser Phe Thr Ile Ser Arg Val Glu Ala Glu
65                  70                  75                  80

Asp Ala Ala Thr Tyr Tyr Cys Gln Gln Trp Thr Phe Asn Pro Pro Thr
                85                  90                  95

Phe Gly Gly Gly Thr Arg Leu Glu Ile Lys Arg
            100                 105


<210> SEQ ID NO 27
<211> LENGTH: 645
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Synthetic Construct

<400> SEQUENCE: 27

caaattgttc tctcccagtc tccagcaatc ctgtctgcat ctccagggga gaaggtcaca     60

atgacttgca gggccagctc aagtgtaagt tacatgcact ggtaccagca gaagccagga    120

tcctccccca aaccctggat ttatgccaca tccaacctgg cttctggagt ccctgctcgc    180

ttcagtggca gtgggtctgg gacctcttat tctttcacaa tcagcagagt ggaggctgaa    240

gatgctgcca cttattactg ccagcagtgg acttttaacc cacccacgtt cggaggggag    300

accaggctgg aaataaaacg gactgtggct gcaccaagtg tcttcatctt cccgccatct    360

gatgagcagt tgaaatctgg aactgcctct gttgtgtgcc tgctgaataa cttctatccc    420

agagaggcca aagtacagtg gaaggtggat aacgccctcc aatcgggtaa ctcccaggag    480

agtgtcacag agcaggacag caaggacagc acctacagcc tcagcagcac cctgacgctg    540

agcaaagcag actacgagaa acacaaagtc tacgcctgcg aagtcaccca tcagggcctg    600

agctcgcccg tcacaaagag cttcaacagg ggagagtgtt agtga                    645


<210> SEQ ID NO 28
<211> LENGTH: 213
<212> TYPE: PRT
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Synthetic Construct

<400> SEQUENCE: 28

Gln Ile Val Leu Ser Gln Ser Pro Ala Ile Leu Ser Ala Ser Pro Gly
1               5                   10                  15

Glu Lys Val Thr Met Thr Cys Arg Ala Ser Ser Ser Val Ser Tyr Met
            20                  25                  30

His Trp Tyr Gln Gln Lys Pro Gly Ser Ser Pro Lys Pro Trp Ile Tyr
        35                  40                  45

Ala Thr Ser Asn Leu Ala Ser Gly Val Pro Ala Arg Phe Ser Gly Ser
    50                  55                  60

Gly Ser Gly Thr Ser Tyr Ser Phe Thr Ile Ser Arg Val Glu Ala Glu
65                  70                  75                  80

Asp Ala Ala Thr Tyr Tyr Cys Gln Gln Trp Thr Phe Asn Pro Pro Thr
                85                  90                  95

Phe Gly Gly Gly Thr Arg Leu Glu Ile Lys Arg Thr Val Ala Ala Pro
            100                 105                 110
```

-continued

```
Ser Val Phe Ile Phe Pro Pro Ser Asp Glu Gln Leu Lys Ser Gly Thr
        115                 120                 125

Ala Ser Val Val Cys Leu Leu Asn Asn Phe Tyr Pro Arg Glu Ala Lys
    130                 135                 140

Val Gln Trp Lys Val Asp Asn Ala Leu Gln Ser Gly Asn Ser Gln Glu
145                 150                 155                 160

Ser Val Thr Glu Gln Asp Ser Lys Asp Ser Thr Tyr Ser Leu Ser Ser
                165                 170                 175

Thr Leu Thr Leu Ser Lys Ala Asp Tyr Glu Lys His Lys Val Tyr Ala
            180                 185                 190

Cys Glu Val Thr His Gln Gly Leu Ser Ser Pro Val Thr Lys Ser Phe
        195                 200                 205

Asn Arg Gly Glu Cys
    210


<210> SEQ ID NO 29
<211> LENGTH: 46
<212> TYPE: DNA
<213> ORGANISM: Artificial Sequence
<220> FEATURE:
<223> OTHER INFORMATION: Primer

<400> SEQUENCE: 29

tgaagacact tggtgcagcc acagtccgtt ttatttccag cctggt                    46
```

The invention claimed is:

1. A monoclonal antibody directed against the CD20 antigen, for therapeutic administration to humans, wherein each of the light chains of said antibody is encoded by murine-human chimeric nucleic acid sequence SEQ ID No. 27, and each of the heavy chains of said antibody is encoded by murine-human chimeric nucleic acid sequence SEQ ID No. 19.

2. The antibody according to claim **1**, wherein the deduced peptide sequence from sequence SEQ ID No. 27 is sequence SEQ ID No. 28, and the deduced peptide sequence from sequence SEQ ID No. 19 is sequence SEQ ID No. 20.

3. The antibody according to claim **1**, produced by a rat hybridoma cell line.

4. The antibody according to claim **3**, produced in the cell line YB2/3HL.P2.G11.16Ag.20, registered at the American Type Culture Collection under ATCC number CRL-1662.

5. The antibody according to claim **1** that is the EMBA603 antibody produced by clone R603, registered under registration number CNCM I-3529 at the Collection Nationale de Cultures de Microorganismes (CNCM).

6. A method, for in vitro activation of FcγRIIIA receptors in immune effector cells comprising combining the antibody according to claim **1** with immune effector cells.

7. A drug composition comprising the antibody according to claim **1**.

8. A method for the treatment of CD20-expressing leukaemia or lymphoma which comprises administering to a patient an effective amount of an antibody according to claim **1**.

9. The method according to claim **8**, in which the leukaemia or lymphoma is a pathology selected from the group consisting of acute B lymphoblastic leukaemia, B-cell lymphoma, mature B-cell lymphoma, small B-cell lymphoma, B-cell prolymphocytic leukaemia, lymphoplasmocytic lymphoma, mantle cell lymphoma, follicular lymphoma, marginal zone MALT-type lymphoma, lymph node marginal zone lymphoma with or without monocytoid B cells, splendic marginal zone lymphoma (with or without villous lymphocytes), tricholeucocytic leukaemia, diffuse large B-cell lymphoma, and Burkitt's lymphoma.

10. The method according to claim **9** wherein said pathology is B-type lymphoid leukaemia.

11. A method for the treatment of B-type Chronic Lymphoid Leukaemia (B-CLL), which comprises administering to a patient an effective amount of an antibody according to claim **1**.

12. The method according to claim **8**, wherein said administration further comprises cells which express FcγRs, such as NK (Natural Killer) cells, NKT (Natural Killer T) cells, Tyδ lymphocytes, macrophages, monocytes or dendritic cells.

* * * * *